# IRON AND STEEL ENGINEER

VOL. XIII MARCH • 1936 NO. III



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1935 • 1936

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# The WEAN CONTINUOUS STRIP PICKLER

The Wean Continuous Pickling Unit consists of machinery especially designed and arranged to produce most efficiently the finest quality of pickled material. In addition, higher speeds are possible and greater tonnage can be procured.

THE CONTINUOUS PICKLING UNIT CAN BE FURNISHED COMPLETE FROM THE HANDLING OF THE HOT STRIP COIL TO THE FINISHED PRODUCT.

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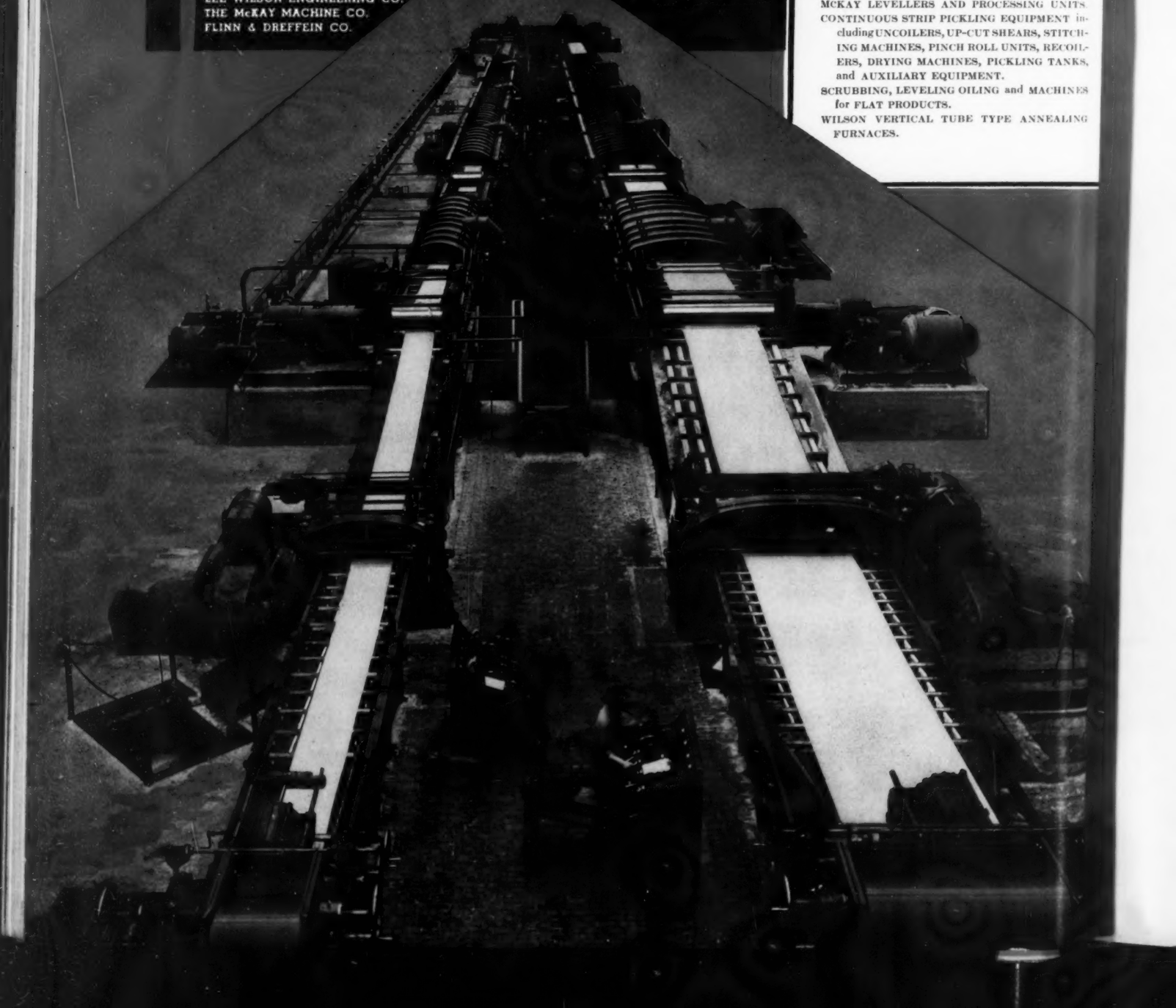

# *Coming Meetings and Papers*

## SPRING ENGINEERING CONFERENCE

**AUSPICES COMBUSTION ENGINEERING DIVISION OF A. I. & S. E. E.**

**APRIL 22-23, 1936** — **Ohio Hotel, Youngstown, O.**

CHAIRMAN
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Carnegie-Illinois Steel Corporation,
Youngstown, Ohio.

SECRETARY
C. J. DUBY, *Chief Engineer,*
Republic Steel Corporation,
Warren District,
Warren, Ohio.

### PAPERS TO BE PRESENTED:

"*Descaling Hot Steel Hydraulically*", by J. E. HOLVECK, Worthington Pump and Machinery Corporation, Harrison, N. J.

"*Circular Furnace for Ingot Heating*", by M. H. MAWHINNEY, Salem Engineering Co., Salem, Ohio.

"*Tension Control in Cold Strip Rolling*", by F. MOHLER, Ind. Engr. Dept., General Electric Company, Schenectady, N. Y.

"*The Measurement of the Temperatures of Hot Moving Objects*", by A. E. KROGH, Brown Instrument Company, Philadelphia, Penna.

"*Refractories in the Steel Industry*", by L. J. TROSTEL, General Refractories Co., Cleveland, Ohio.

"*Control and Recording of Rolling Mill Pressures*", by M. STONE, United Engineering and Foundry Company, Pittsburgh, Pa.

"*A Description of 43" Hot Strip Mill", Carnegie-Illinois Steel Corporation, McDonald, Ohio*, by L. N. MCDONALD, General Supt., Carnegie-Illinois Steel Corp., Youngstown District, Youngstown, Ohio.

### SPECIAL FEATURE

Thursday Afternoon, April 23, Inspection trip to 43" Hot Strip Mill, Carnegie-Illinois Steel Corporation, McDonald, Ohio.

At the special request of the Carnegie-Illinois Steel Corporation officials, the members and guests are asked to use the transportation facilities which the Association will provide.

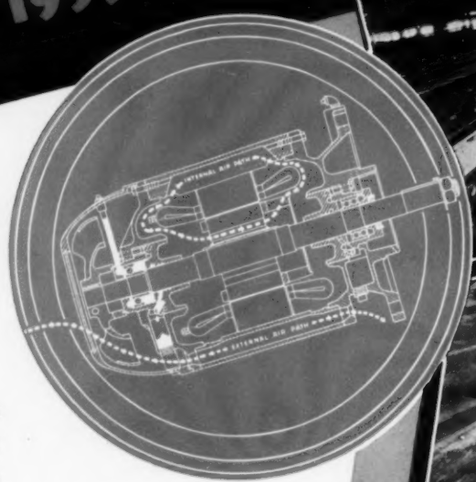
# MORE THAN 2000

## *Westinghouse Run-Out Table Drives*

## WENT INTO AMERICA'S STEEL MILLS IN 1935 • • •

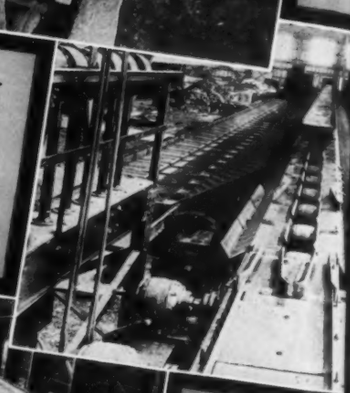
Above—Type F[illegible] motor with [illegible] closed, fan-cool[illegible]

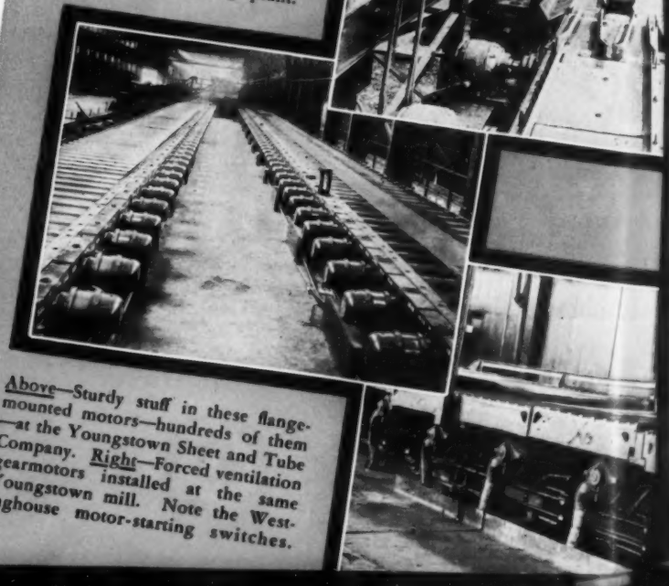
An early insta[illegible] the Laclede St[illegible] Alton, Il[illegible]



Cross-section of Westinghouse run-out table motor—dual ventilation, rigid cast frame, patented bearing construction—three reasons why these motors fill the bill.

Above—One of the first applications of individual motor drives to run-out tables—in the Acme Steel plant at Chicago. Installed in 1924—still handling steel at low cost. Right—Double extended shaft motors at the A. M. Byers Ambridge plant.





Above—Sturdy stuff in these flange-mounted motors—hundreds of them—at the Youngstown Sheet and Tube Company. Right—Forced ventilation gearmotors installed at the same Youngstown mill. Note the Westinghouse motor-starting switches.

● Ever since individual drives were first used for run-out tables, Westinghouse has figured prominently. Here's a list of Westinghouse motor and gearmotor installations for last year:

| | |
|---|---|
| At a Gary steel plant | 54 units |
| At a Youngstown steel plant | 516 units |
| At a Buffalo steel mill | 688 units |
| At another large Gary mill | 784 units |
| Total - - - | 2,042 units |

More than 2000 Westinghouse motors and gearmotors for run-out tables in *one year!*

Sales like that mean something—most obviously, that Westinghouse equipment has features steel men are looking for.

J 90071

WESTINGHOUSE 1886 W 1936 GOLDEN JUBILEE

# Westinghouse

# "The Purposes of Writing"

THE RECORDS of the Association include a number of very valuable papers prepared not only by members but others interested in the purpose of the Association. While valuable from the standpoint of the subject treated, the research, test and operation data submitted, these contributions are of special merit on account of their stimulating and guiding influence towards the continual betterment of the products of the iron and steel industry. This striving for better things gives us our interest in our work and the urge to do our bit.

One of the most broadening effects of experience is that it enlarges ones vision and gives to the study of a problem that intuition which in most cases is so essential to the successful solution. Too few of us take the trouble to concentrate on our own case, first to obtain a real appreciation of the probable value of our experience and then endeavor to estimate what help a review of this experience and information it has developed, will be to others interested in similar work.

Writing or the preparation of an article to the man of experience is merely the unfolding of the things he has learned and which he knows he knows. He understands what is a generally accepted statement, that a problem well stated is half solved and he appreciates that until this is done no real progress towards the elimination of a limiting factor is made. To make his findings logical and thorough, he first prepares a structural outline and with a method to follow, he will naturally thoroughly develop and properly coordinate the facts that have a bearing on the subject he is discussing.

The preparation of a paper is of greatest benefit to the author as it tends to systemize his work and surely will broaden his view of the factors of the subject and thus greatly aid in the finding of ways and means to improve methods of production and quality of goods.

Everyone desires to build friendships and to improve their opportunities. Writing is one way to do this for it lets people see you as you are.

We urge that our members and others interested give this matter of discussion of Iron and Steel Industry subjects their earnest consideration and assist directly or indirectly in adding to our list of valuable papers.

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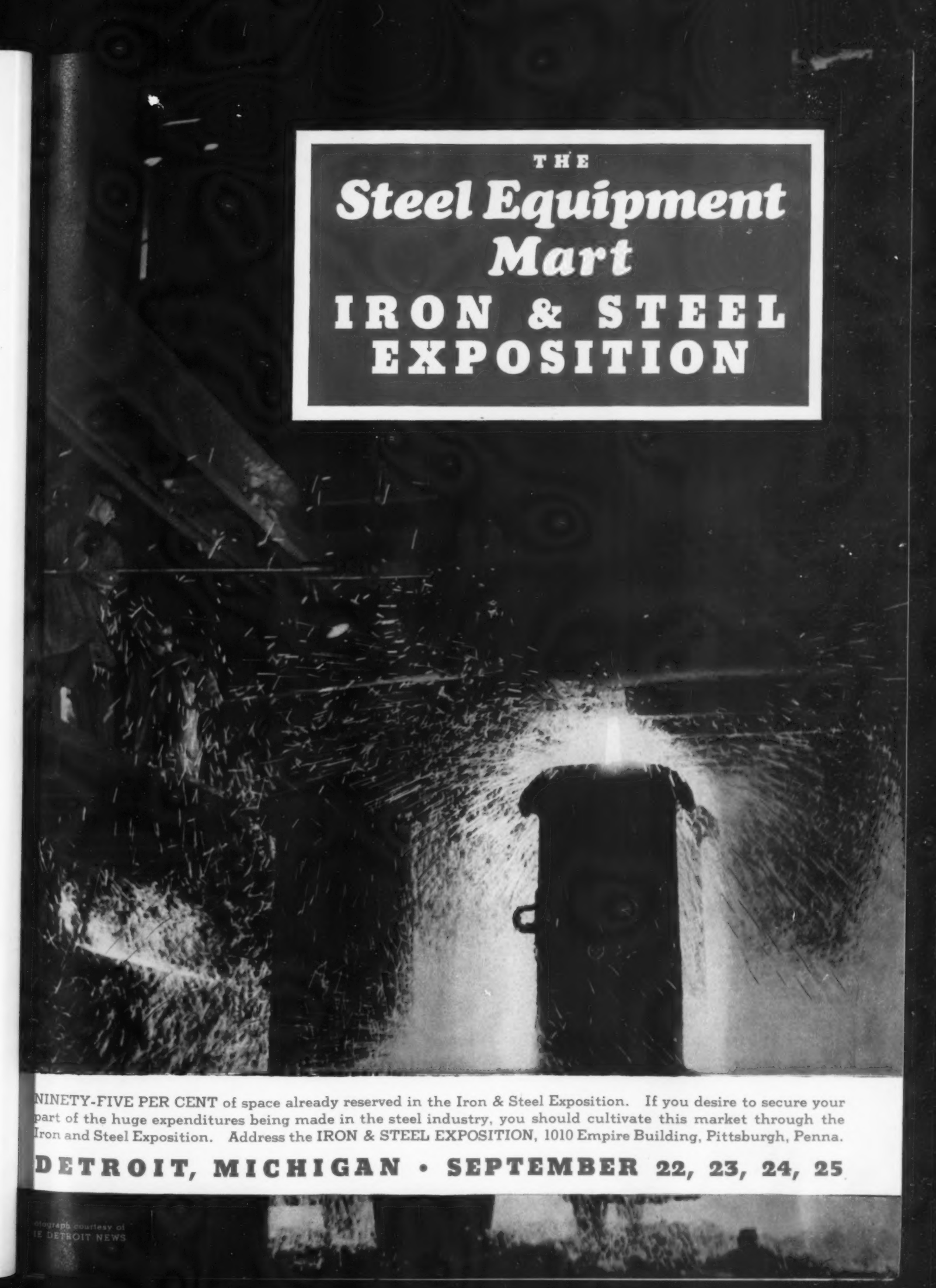


NINETY-FIVE PER CENT of space already reserved in the Iron & Steel Exposition. If you desire to secure your part of the huge expenditures being made in the steel industry, you should cultivate this market through the Iron and Steel Exposition. Address the IRON & STEEL EXPOSITION, 1010 Empire Building, Pittsburgh, Penna.

**DETROIT, MICHIGAN • SEPTEMBER 22, 23, 24, 25**

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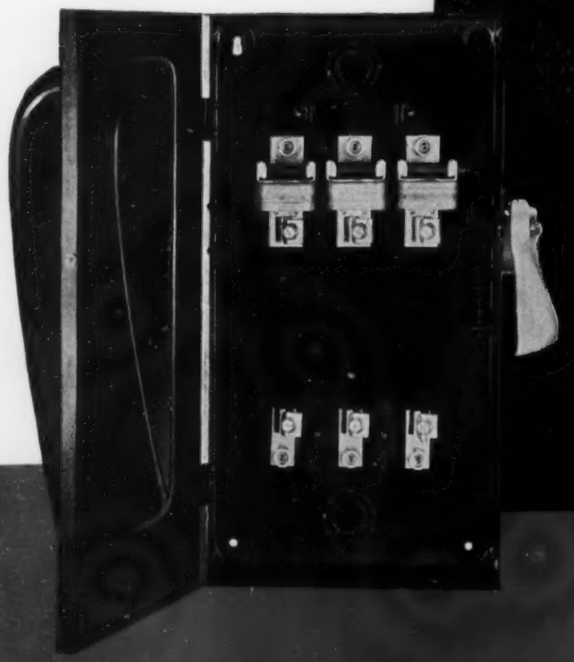
IE DETROIT NEWS

# BULL DOG Announces th

Only **BULL DOG**
has the New Exclusive

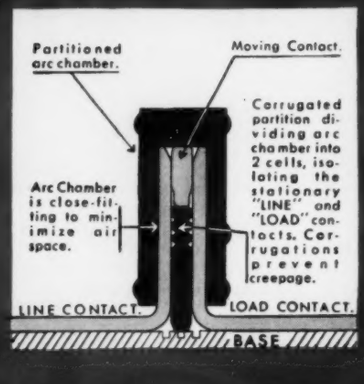
## Vacu-Break

**PRINCIPLE**



Modern
Stylined
Cabinet

**If the safety switch that you are now buying hasn't the new *Vacu-Break* principle with floating contact, it is old-fashioned. Here is the *SAFEST* safety switch ever designed. The principle is so simple you will wonder that someone hadn't thought of it before.**


Partitioned arc chamber.
Moving Contact.
Corrugated partition dividing arc chamber into 2 cells, isolating the stationary "LINE" and "LOAD" contacts. Corrugations prevent creepage.
Arc Chamber is close-fitting to minimize air space.
LINE CONTACT.
LOAD CONTACT.
BASE

### Full "ON" Position . .

The partitioned arc chamber, with moving contact floatingly supported therein, moves on the stationary self-guiding "LINE" and "LOAD" contacts.

ILLUSTRATING THE

# the REVOLUTIONARY NEW Vacu-Break SAFETY SWITCH

## . . . Setting a New Standard of Performance in Circuit Rupturing

The amazing VACU-BREAK principle of arc control is startling in its simplicity yet most effective in performance.

Notable features incorporated in VACU-BREAK Safety Switches include: Better Rupturing Performance — Double Sealed, minimum Arc — Enclosed Moving and Stationary self-aligning Contacts — Better Conductivity and sturdy yet simple construction with fewer parts. Modern, stylined, COMPACT cabinets with adequate wiring room.

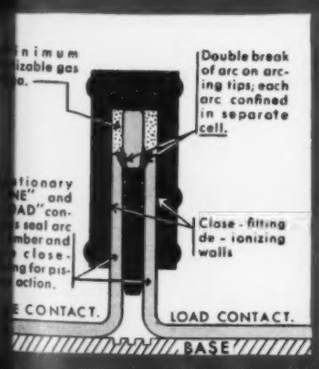
All "LINE" and "LOAD" wiring terminals in VACU-BREAK Switches are solderless WIRE GRIPS. They save wiring time and soldering material and make a cleaner, more workmanlike job while insuring better contact.

*Write for 16 Page Bulletin*

# BULL DOG ELECTRIC PRODUCTS CO.

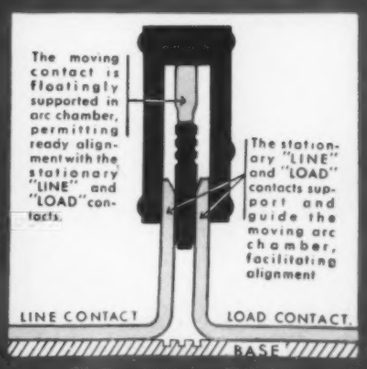
**DETROIT MICH. U. S. A.**

In Canada: Bull Dog Electric Products Co. of Canada. Ltd., Toronto, Ont.




### Rupturing the Circuit . .

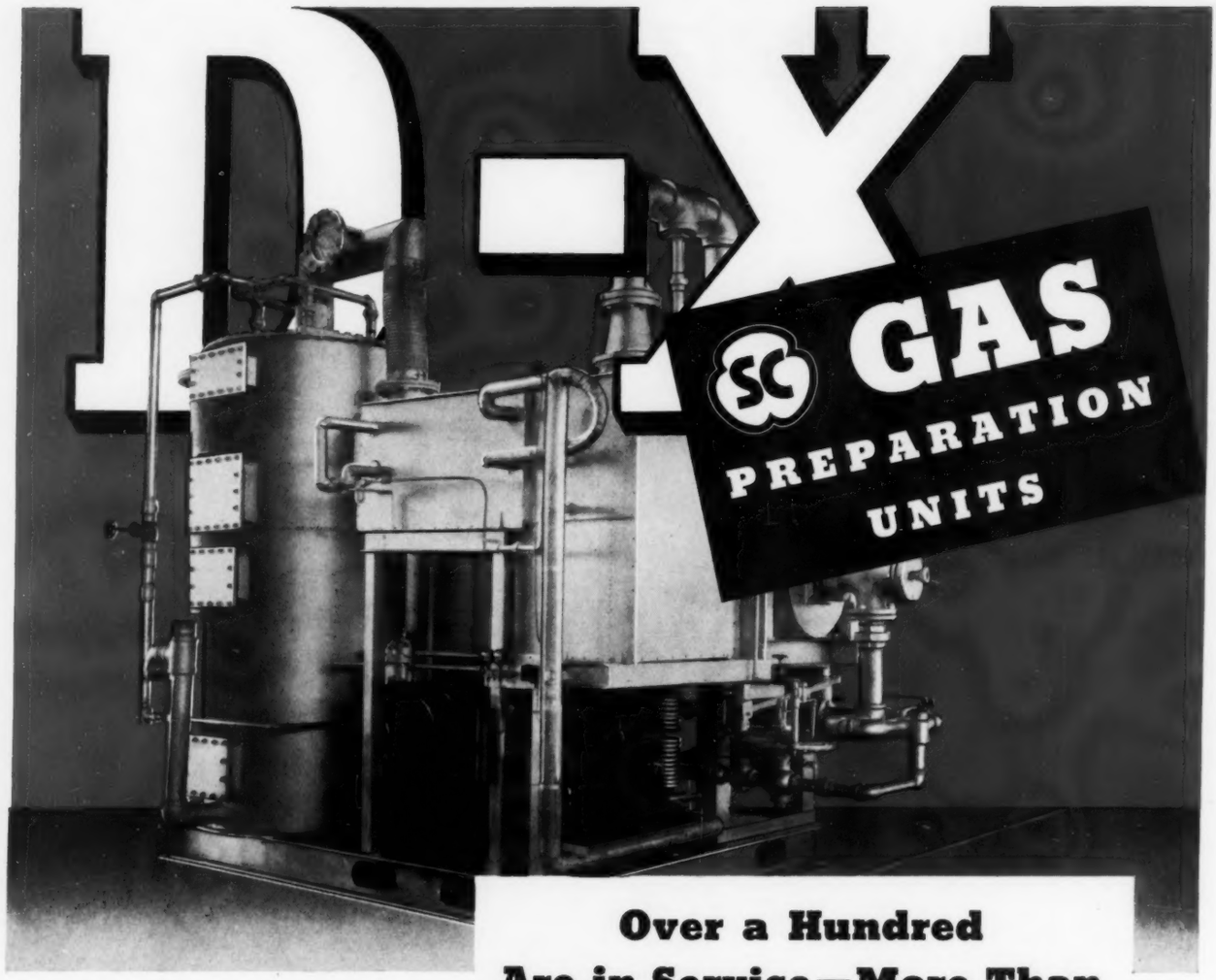
The quick outward movement of the housing on the close-fitting stationary contacts creates a piston action tending to eVACUate air from the arc chamber.


The moving contact is floatingly supported in arc chamber, permitting ready alignment with the stationary "LINE" and "LOAD" contacts.
The stationary "LINE" and "LOAD" contacts support and guide the moving arc chamber, facilitating alignment
LINE CONTACT
LOAD CONTACT.
BASE

### Full "OFF" Position . .

The stationary "LINE" and "LOAD" contacts remain partly inserted in enclosed arc chamber, effectually sealing same against dust and dirt.

**Vacu-Break PRINCIPLE OF CIRCUIT RUPTURING**




## Over a Hundred Are in Service—More Than Any Other Make

Developed to produce an inexpensive gas where controlled atmospheres are required in present-day heat treating practice, the Surface Combustion D-X Gas Preparation Unit is now installed in many large steel plants, displacing expensive prepared gases, raw natural or city gas at substantial savings. Costs are *one-third* to *one-sixth* as much as your present costs if you are using raw natural or city gas, and Surface Combustion D-X Gas produces a superior product and finish in bright annealing, de-oxidizing of steel sheet and strip.

D-X gas can be used throughout the entire heating and cooling cycle since it is *non-explosive, oxygen-free,* of *uniform composition, dehydrated* and *clean.* No expensive chemicals or materials have to be renewed. D-X unit is entirely automatic except for starting and stopping, and is delivered ready to operate when connected to gas, water and electric systems. D-X units are built in standard sizes, to produce from 500 to 15,000 cu. ft. per hour. Ask an SC Engineer about their application in your plant, or write SURFACE COMBUSTION CORPORATION, TOLEDO, OHIO

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# *Consider the* MANUFACTURER

## *Outstanding*

Complete mill lubrication installations engineered by De Laval during the past year are those in connection with:

FORD MOTOR CO.—Detroit
- 44″ Blooming Mill
- 56″ Hot Strip Mill
- 84″ Cold Reversing Mill
- 56″ Tandem Mill
- 2 Tempering Mills

BETHLEHEM STEEL CO.—Lackawanna
- 79″ Hot Strip Mill
- 75″ Tandem Mill
- 42″ Tandem Mill
- 90″ Tempering Mill
- 2–75″ Tempering Mills
- 54″ Tempering Mill

BETHLEHEM STEEL CO.—Sparrows Point
- 42″ Tandem Mill
- 2 Tempering Mills

WEST LEECHBURG STEEL COMPANY
- 4 Steckel Cold Reversing Mills

ZAPOROJSTAL STEEL WORKS—U. S. S. R.
- 66″ Hot Strip Mill
- 66″ Tandem Mill
- 66″ Cold Reversing Mill

## REPUTATION

After nearly sixty years of specialized manufacturing experience, De Laval presents to the Steel Industry a completely new and modern type of centralized pressure lubrication system. It is designed to automatically and continuously deliver clean, dry and correctly metered lubricant at controlled temperatures to all points of modern rolling mills requiring lubrication.

De Laval Lubrication Systems have many exclusive features which make it possible to retain the same oil in continuous use indefinitely. These exclusive features minimize repair costs and guard against shut-downs by improving lubrication efficiency. Most important of all—they prolong equipment life and reduce mill lubricating costs.

## FACILITIES

De Laval maintains a thoroughly competent and complete engineering staff with all modern facilities, available to clients at all times. This results in lubrication equipment design co-ordinated with that of the mill builder. Each piece of equipment is specially engineered to fulfill the duty it is to perform and yet fit into the allotted space.

De Laval's own engineers are available to supervise field erection work, if desired.

## EXPERIENCE

For many new mills and as replacement equipment on old ones, this modern, economical De Laval Lubrication Equipment is proving to be the last word in efficiency.

*Engineered by---*

**DE LAVAL**

# The De Laval Separator Co.

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DE LAVAL PACIFIC CO.
61 Beale St.,
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TRIMMING, LEVELLING, AND SHEARING EQUIPMENT, INCLUDING
MESTA PATENTED FLYING COLD SHEAR AND PATENTED FEED REEL

**Mesta Finishing Equipment is designed to operate with speed, accuracy, and without injury to the surfaces of the sheets.**

**Mesta Feed Reels (Moxley Patent) receive the coil and center it quickly. Mesta Trimmers are built heavy enough, with sufficient adjustments, to maintain accurate trimming throughout the full length of the coil. Mesta Patented Combination Levellers and Rotary Flying Shears have established themselves as the best method of meeting high production schedules.**

**MESTA MACHINE COMPANY · PITTSBURGH**

# DESIGNING FOR LUBRICATION

## ITS IMPORTANCE IN MILL EQUIPMENT

By CHARLES R. HAND, Lubrication Engineer
Bethlehem Steel Company
SPARROWS POINT, MD.

**Paper presented before the Philadelphia and Pittsburgh Sections of the A. I. & S. E. E.**

▲ IN THE CONSIDERATION of the many phases of steel plant lubrication, design of equipment, method of application of lubricants, and type of lubricants used are the predominant factors. The first and most important is design. All steel plant engineers have a vital concern in the original design of equipment. The lubricating engineer, as well as the mechanical and electrical engineers finds, in many cases, after the equipment has been installed that necessary improvements can only be made by dismantling, machining and changing the original design. It is well known that cost of these changes is sometimes too high for complete correction. These conditions then continue to exist causing delays, loss of bearings, gears and lubricants, until such time as all factors demand their correction. This sometimes means years of waiting.

There has been much research and development in the design of bearings, gears, seals and oil systems in the past few years. The automotive designers have made the greatest advances in this field. The machine tool manufacturers have been close behind. The small gear reductions now marketed show the effect of the studies made by their designers. Many manufacturers of miscellaneous steel mill equipment have not made the progress shown in other lines.

It is the purpose of this paper to endeavor to awaken buyers of steel mill equipment to the need of insistance upon the adoption of modern design methods by the manufacturers of much of our steel m ll machinery, and to a greater foresight on the buyers' part in planning with the equipment maker. I am not affirming that the fault has all been on one side. Some cases will be presented to illustrate defects in the original design and to show what has been done, in the field, to improve the conditions. These cases cover bearings, gears, seals and oil systems and will be considered in the order stated.

### BEARINGS

Failures of bearings have been caused by one or more of the following reasons.

1st.—Improper material in bearings.
2nd.—Insufficient area.
3rd.—Clearance too close to accommodate frictional heat.
4th.—Improper anchorage causing poor heat transfer.
5th.—Entry holes for grease or oil too small or improperly placed.
6th.—Poorly designed grooving.
7th.—Oil rings too light or too heavy for speed of shaft.
8th.—Oil rings dipping too deep in oil.
9th.—Oil rings separating.
10th.—Improper lubricant.

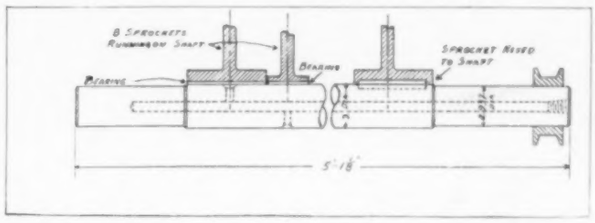
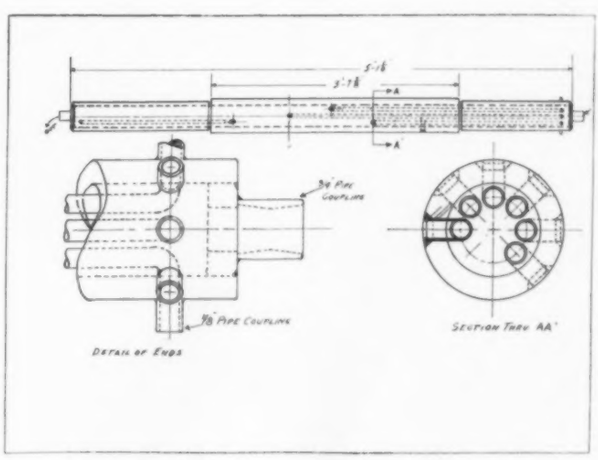



Fig. 1

Figure (1) shows a sprocket shaft installed in front of a continuous furnace, used to heat sheets to 1500° F. This shaft carries the delivery chains from the furnace door to the rolling mill. The chain is not driven by this shaft. The 9 sprockets were originally filled with standard bronze bushings. The shaft was drilled for grease lubrication. Each bushing was supposed to get

Fig. 2



grease from the same center hole. A hole was drilled into this center hole for each bushing. After a week's run, the middle bushings began to show rapid wear. At the end of three week's run, all except the first two bushings had either stuck or ground out. This failure was due to two reasons, first, standard bronze is not suitable for use with high temperature, second, one grease hole can only feed one bearing. The grease followed the path of least resistance and the balance of the bearings got little or none.

Figure (2) shows the shaft after individual pipes had been fitted to each bearing and water cooling provided. In addition high lead, or plastic bronze, was used for bushings. These changes have resulted in satisfactory operation. This shaft and bushings are in good shape after two years service.

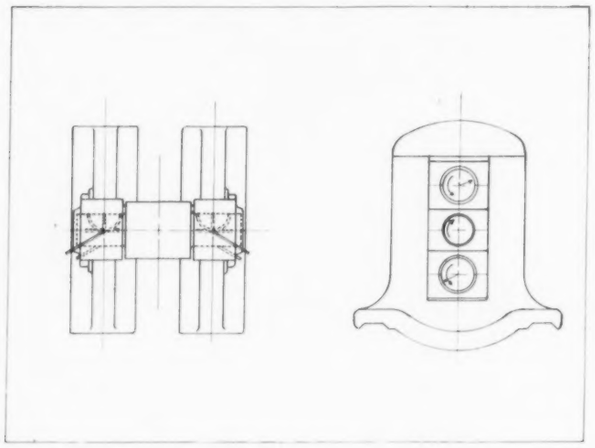


Fig. 3

Figure (3) and (4) show a large mill pinion bearing originally fitted with lead babbitt. A study was made of the causes of several failures. It was found that the grooving was not supplying oil to the bearings at the proper places. The bearings had the type of grooves used by the majority of mill designers, that is two curved grooves extending from one side of the bearing to the other and forming a semi-circle in the babbitt. It was found that the grooves in the original bearings were located at the point where the greatest load was carried. After the bearings had been rebabbitted, the grooves were cut in each bearing so as to lead oil to a point ahead of this heavily loaded area. The results have shown the value of the study and time spent to make the changes. In addition, the lead base babbitt originally used in these pinion bearings was replaced with tin base babbitt, on account of the extreme impact conditions existing on these bearings. It is not intended to state that tin base babbitt should replace lead base babbitt on all main mill pinions, but only in cases where impact is unusually severe.

Similar studies and changes have been made on crane journals, gear drive bearings and general plant machinery. In some cases high lead bronze has been used to replace standard bronze, in others phosphor bronze has been used. In a few cases the loads have made it necessary to use ball or roller bearings to carry the shaft originally carried by bronze or babbitt bearings. In some cases roller bearings have failed and bronze sleeves used to replace them have given three to four times the service.

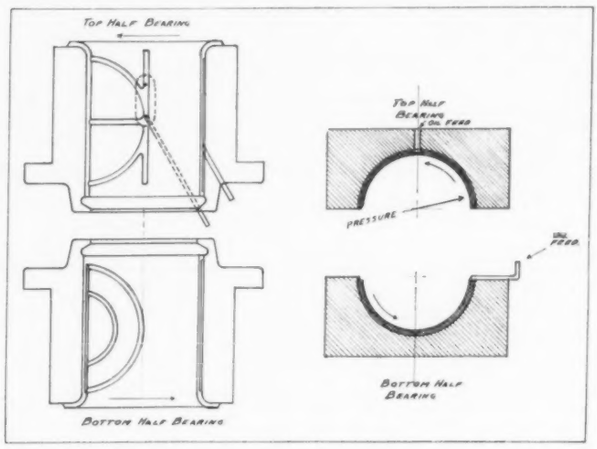
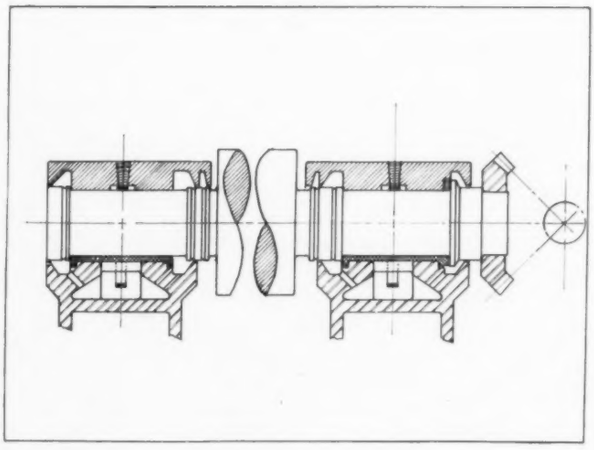



Fig. 4

Figure (5) shows a bearing on a blooming and slabbing mill roll table. This bearing failed due to insufficient area. The movement of slabs from side to side during rolling operation wore out the thrust collars and bearing shell. These bearings were originally fitted with oil cellars and rings. The method used to seal them was unsatisfactory. Scale and mill dirt entered the bearing and rapidly filled the oil cellar. This stopped the ring and bearings failed after two to three weeks run. On these bearings where the cellars were not filled with dirt, longer life was obtained but the small area under the bearing was insufficient to carry the load and the bronze was beaten down into the seat. The oil cellars were fitted with a steel block and welded up so as to get a solid seat under the brass. A pressure grease fitting was installed on the top of the bearing cap and grease forced in with a pressure grease gun. This showed improvement in the life of the radial bearings. The thrust collars, however, continued to

Fig. 5



wear and mitre gears ran out of mesh. This allowed them to beat themselves to pieces in a very short time. After several failures it was shown that the thrust collars were too small. It was then necessary to install a thrust bearing on the idle end of the roller to hold the gears in mesh. Figure 6 shows the method used to hold this thrust bearing in place. This has been the means of extending the life of the gears from three months to five years and still going. Bearing life is measured in years instead of weeks.

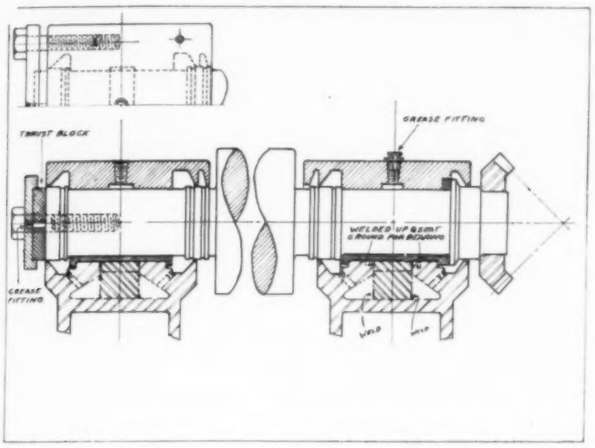
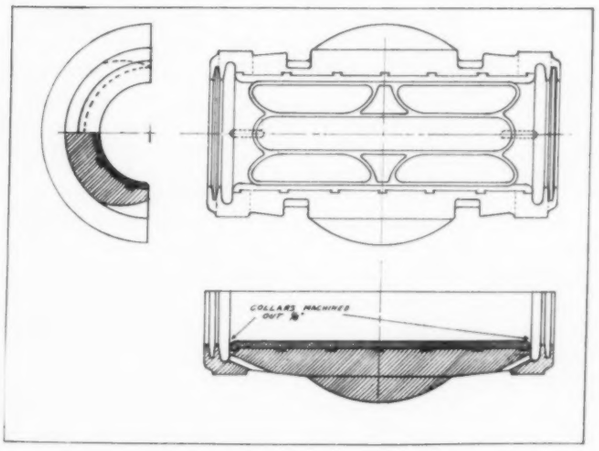



Fig. 6

Figure (7) shows a high speed bearing on a main mill reduction gear drive. This bearing had an original clearance of $\frac{1}{16}$" between the shaft and the small collars on each end. Trouble developed on one end and babbitt was damaged. It was discovered that the oscillation of the shaft was causing the trouble. The gears were of the herringbone type. The meshing center had not been set in line with the high speed bearing center. The pressure exerted by the gear in forcing itself to the proper position was overloading this small collar. This center was found to vary with the load on the drive. The small collar on each end was cut back $\frac{1}{8}$" and the bearing gave no further trouble. This was one of several similar drives which were all changed to the same clearances. This solved the trouble in all cases.

On another drive of identical design this bearing ran hot several times and had to be scraped in. Each time it was noticed that the grooves had filled with loose dirt and babbitt. Finally the bearing was rebabbitted and sides freebored as shown on Figure (8). All grooving was eliminated from the bottom half of the bearing. The direction of rotation of the shaft raised the shaft off the bottom bearing while the load was being exerted but it dropped back again when load was released. This was causing a different load area for each period. Since the change was made no further trouble has occurred. The grooving in bottom of bearings or pressure area breaks oil film and allows oil to escape at ends of bearings. The free boring of bearings has been developed and used by motor manufacturers for a considerable time and results have been excellent. Not enough study has been given by steel mill designers to this important problem. At least they have failed to adopt in many cases, the lessons learned by the motor manufacturers. It is true that motor loads are low when compared to those carried by gear drives and mills in steel plants. However, on all gear drive bearings where the free bore has replaced the grooving, the results have shown a reduction in the operating temperature and the loss of bearings has ceased. There have been many different systems of grooving and in some cases, the machinist adds his own ideas to some intricate set of grooves. The results has been a reduction in pressure area and lost bearings. Some bearings noted, have had as much as 40% area cut away for grooves.

Fig. 7



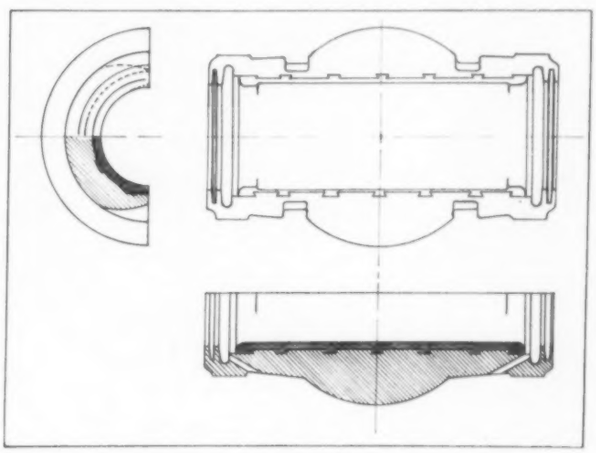



Fig. 8

On mill tables and drives, design in many cases does not allow for heat transmitted from the hot ingots or slabs. In a few cases the table bearings were designed for .010" radial clearances. Motors began to labor and stall as soon as the table heated. It was necessary to shut down and machine the bearings out to $\frac{1}{16}$" clearance to allow for expansion and grease film. This allowed the table to run without undue power loss.

Figure (9) shows a large hinge bearing on a plate mill tilting table which oscillates through an arc of only 4 degrees. This bearing was originally designed for bronze bearings with oil lubrication by means of

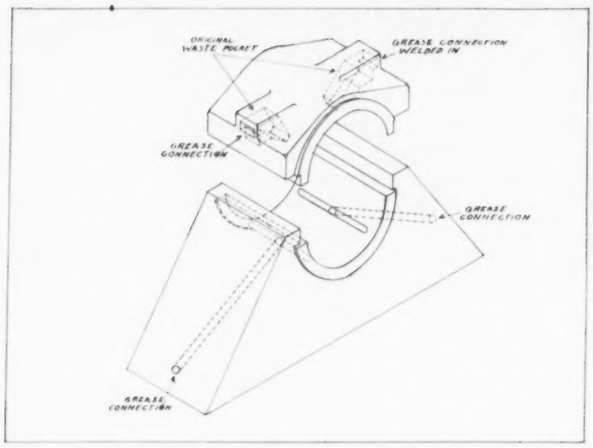
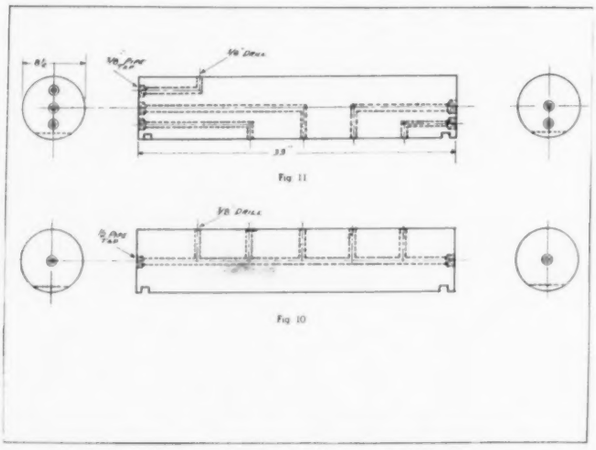



Fig. 9

the waste packed box on the top of the cap. This soon proved unsatisfactory. Salt, salt water used on mill and scale entered and bearings failed. This allowed table to settle and increased the power necessary to operate it. The oil and waste box was cleaned out and welded up tight. A pressure grease fitting was installed in the side of the box. This showed slight improvement. Due to the partial revolutions made by the shaft, no grease was carried into the loaded area and sufficient pressure could not be exerted from the cap to drive it under the shaft. It was found necessary to drill additional holes into the load area from the bottom of the bearing housing. This has shown improvement and bearings are expected to last for a much greater period.



Figs. 10 and 11

Figure (10) shows a sheave pin on a 150-ton ladle crane spreader. The original design had one hole with outlets to each sheave bushing. This was very unsatisfactory and loss of bushings continued until individual holes were drilled for each sheave. Grease pressure fittings and guns have extended the life of bushings from a few months to as many years, but the fittings and guns were not able to force grease to more than one bearing with the holes leading from a common feed. It is necessary to drill sheave pins for individual feed as shown in Figure (11), whether grease or oil is used.

In the use of oil rings much damage has been caused by heavy rings wearing the shaft. This is particularly true on centrifugal pumps and motors running at high speed. The design of bearing oil wells in most cases permits the rings to dip too deep into the oil. The speed of the ring is retarded and rapid wear of the ring results in all cases and the shafts in most cases. With rings that are too light, too much dip usually causes the ring to stall and bearings to run hot and stick. The lowering of the oil level in the well has solved many problems of this type. The amount of oil delivered to the top of the shaft is increased and wear decreased by permitting the rings to travel as near to the shaft speed as possible. On large bearings using rings, weight of ring and depth of dip is most important. Allowing ring to dip three or four inches will result in slowing the ring to the point where no oil reaches the top of the shaft. On rings above 18″ in diameter, a dip of twice the thickness of the ring will give best results. This has been proven on rings up to 40″ in diameter, operated at speeds from 17 RPM to 150 RPM carrying oils from 300 seconds saybolt to 1700 seconds saybolt.

Many and varied are the designs used for rings. The solid square section ring, although the best cannot, unfortunately, be used in all bearings. The method used to fasten two or more pieces together to form a ring has been the cause of many damaged bearings. Bolts, rivets, or clamps which extend beyond the outside edges of the ring are liable to become fouled and prevent the ring turning. The use of the simple four piece ring held together with counter sunk head screws having the thread end slightly peened and filed smooth, has solved many problems of this type in Figure (12).

Improper lubricants do not have as much effect on the operation of mills as most operators believe. Temperatures, loads and speeds govern the selection of the lubricant. It is necessary, however, to use a lubricant that can be kept in the bearing. In some cases the impossibility of keeping dirt, water, salt or scale out, makes the use of grease necessary. Occasionally a heavier oil can be used to improve bearing life. This is, however, always at the cost of increased power and operating temperature. In the majority of failures, the lubricant used cannot be condemned for the failure. A combination of the causes mentioned due to design, sometimes seem to indicate improper lubricant. However, when design is corrected, the poorest lubricants give good service.

## GEARS

Failures of gears have been caused by one or more of the following causes.

1st.—Steel too soft, steel too hard.
2nd.—Porous castings, improper analysis.
3rd.—Insufficient forging on large hydraulic forged pinions.
4th.—Improper tooth angle.
5th.—Insufficient tooth contact.
6th.—Bearings too small to hold alignment.

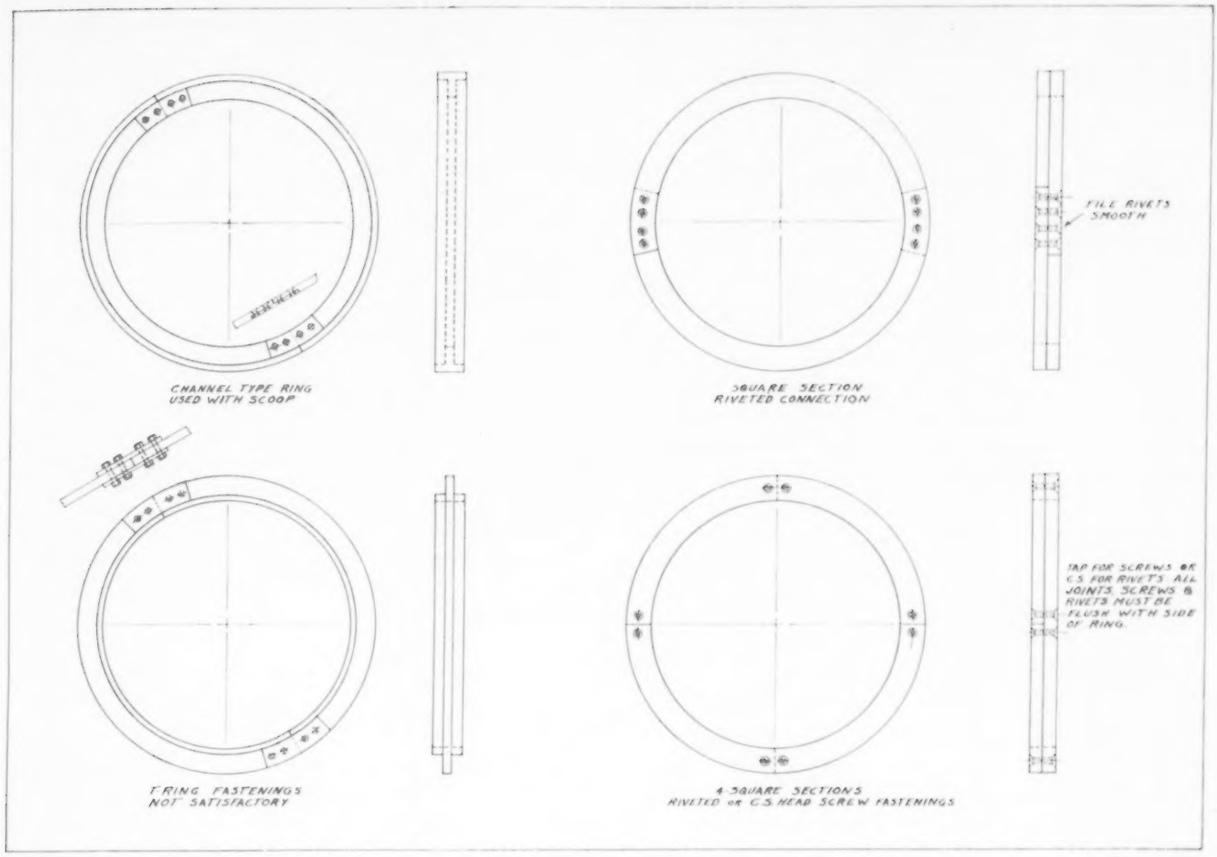



Fig. 12

7th.—In Herringbone type attempting to hold thrust of both high and low speed gears.

8th.—In worm gearing in sufficient thrust area to hold worm shaft.

9th.—Bearings split wrong way.

Figure (13) shows a large pinion that wears rapidly due partly to improper tooth angle and too few teeth in contact. The loads imposed on these pinions are not excessive. Heavier loads are carried on many pinions and gears having a one diametral pitch tooth instead of the ½ diametral pitch specified for this drive. On many gears and pinions the analysis and heat treatment has been given little if any attention. More attention should be given to calculating loads, studying tooth action and quality of material in gears.

Figure (14) shows the bearings used on a 75-ton open hearth crane line shaft. The small bearings here rapidly wear and allow the pinion to run away from the gear.

Fig. 13

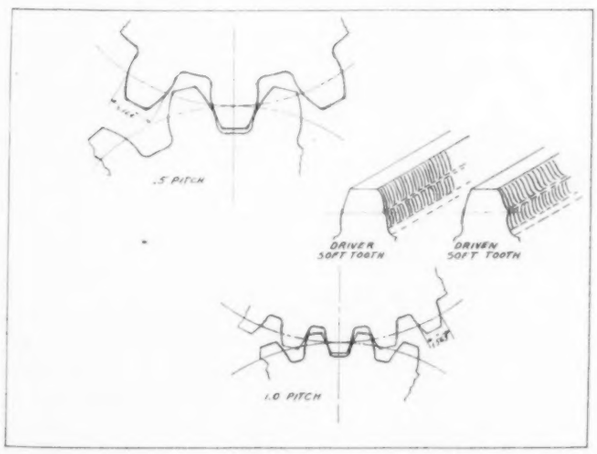
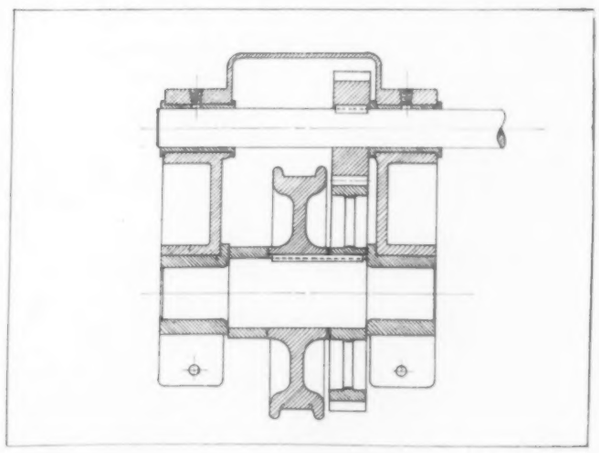


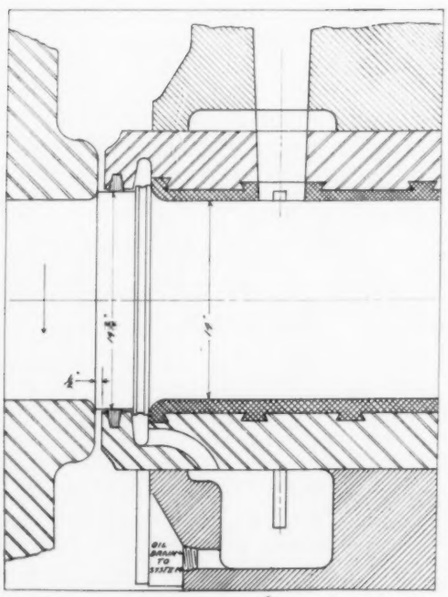

Fig. 14



This rapidly wears out the gear and pinion, but particularly the pinion. Continuous operation wears the journal bearing and allows the crane to settle down. The gear and pinion are driven deeper into mesh, sometimes to the extent of carrying part of the weight of the crane. This is all carried on the bearing cap and of course, the bolts holding the cap should be heavy enough to carry this load also. They seldom are. The result is these bolts stretch and the shaft begins to rock from side to side. Grease grooves are usually put into the cap. It is almost impossible to get grease into the bearing and properly distributed when the load is carried on cap. Bronze bushings soon grind out. The only solution for this condition is to use roller bearings or MCB type bronze bearings of ample area to carry the weight and maintain the correct distance between gear and pinion centers. In mitre and bevel gears the bearings are the most frequent cause of damaged gears. Difficulty in keeping bevel gears in mesh is frequently caused by insufficient thrust area on bearing collars.

On worm gear drives used with arm and lever, on tables, shakers, etc. insufficient thrust causes rapid destruction of worm gear and worm. The worm gear, usually made from bronze or cast iron, shows the first signs of wear. As the thrust bearings wear and the clearance increases, the worm is permitted to move back and forth with a hard bump and teeth soon break. This condition has been noted on ball and roller bearings as well as plain thrust bearings. On all gear drives for this service, ample thrust bearings must be provided, either within the case or on the outside. The use of helical in place of spur drives is being too slowly adopted by the steel industry.

Fig. 15



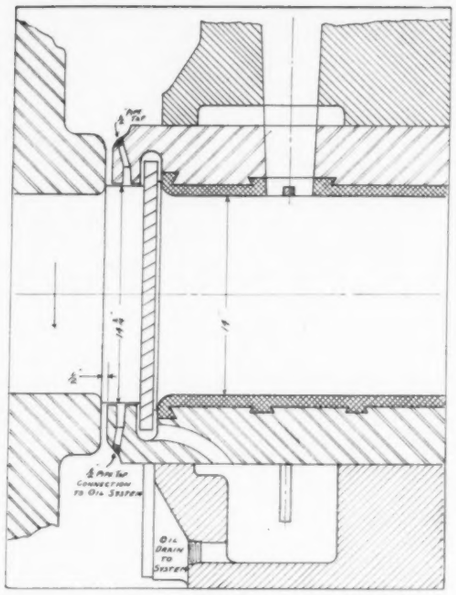


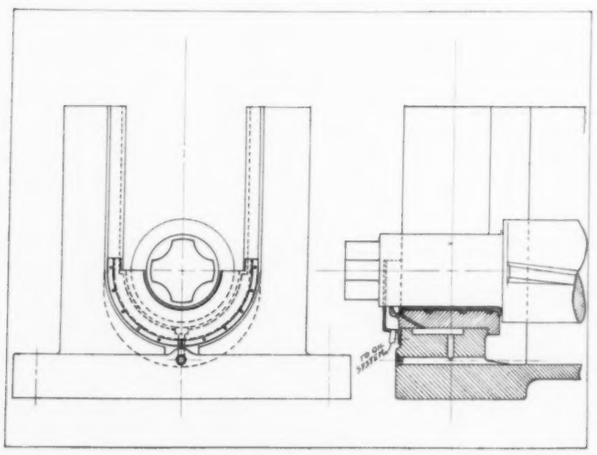
Fig. 16

## SEALING

The means for sealing bearings and gears against outside contamination and to prevent loss of lubricant from the inside used by many designers, leaves much to be desired. In some cases no means is provided. In others, felts are forced into grooves. In still others, labyrinths are cut into the housings. None of these are entirely satisfactory.

Figure (15) shows gear drive bearings where felts were used for seals. This was wholly unsatisfactory and two to three barrels of oil were lost each month. The motion of the flywheel created sufficient suction to draw the oil out between the felts and the shaft. It was then thrown off and into the flywheel case. The

Fig. 17



felts were renewed several times without success. It was then decided to machine the bearings out and install an oil throw ring. Figure (16) shows the flinger rings and additional drains installed in these bearings to prevent loss of lubricant. This was designed to overcome suction of flywheel, but not to draw air into bearing. This has given excellent results.

Oil leakage out of mill pinion cases has caused much concern. In most of these cases, it has been necessary to make sheet metal pans and attach them to the pinion housings under the leaking bearings. This has been done by bolting and in some cases, welding them on. Pipe connections are then made back to the central oil system. This is shown on a mill pinion in Figure (17). In other cases where speed is sufficient, oil throwers on shaft prevent oil creepage. Where speeds are low, babbitt oil wipers are effective.

On some large mill table gear cases it has been necessary to weld covers oil and water tight. When inspections or repairs are made, an acetylene cutting torch is used to cut the welds away. When reassembled, they are again welded tight before the mill begins to operate.

### CENTRAL OIL SYSTEMS

The advent of the large pressure circulating oil system has raised many additional problems. The troubles encountered have caused many gallons of oil to be lost in addition to gear and bearing failure.

Systems have been designed with tanks too small, pipe lines too small, particularly drain lines, filters too small and small sight feeds on bearings which could not be seen through at night. Overflows from bearings improperly placed have helped to keep the floors and mill sections full of oil which was leaking out. Threaded pipe always gives trouble due to leaks. Threads are rarely tight on large mill pipe lines. Welds are best.

In some cases large systems have been provided with long feed and drain lines to and from widely separated equipment. Insufficient pitch to drain lines does not allow the oil to drain back and sewers are well oiled. Drain lines should have at least 4″ of fall for every ten feet of line. Very little thought is given to the fact that oil to the value of $7,000.00 may be contained in one mill system but one broken 6″ flange out of sight under the mill, may put one half of the entire amount into the sewer before any notice is taken of the loss.

The examples given are taken from actual experiences in the lubrication of large steel plants. None of them are unusual. None of the cures are new and no credit is claimed for originating them. They have been necessitated by the incorrect design of the equipment. The steel business is, we are told, on the eve of much remodeling and modernization of rolling mill equipment. Evidences of this are apparent in many plants. Many designs now being submitted by manufacturers show these same old faults. The users and buyers must insist on the best design, be willing to pay for it and take no compromise.

# DISCUSSION

## PHILADELPHIA SECTION

PRESENTED BY

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F. O. SCHNURE, Elec. Supt., Bethlehem Steel Co., Sparrows Point, Md.

M. RESWICK, Standard Oil Company of New Jersey, New York, N. Y.

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W. G. McDONALD, Westinghouse Electric & Mfg. Co., Philadelphia, Pa.

W. S. WAGNER, Plant Engr., Philadelphia Coke Co., Philadelphia, Pa.

D. L. SASSER, The Texas Co., Norfolk, Va.

E. S. GLAUCH, Mech. Eng., Jos. Dixon Crucible Co., Jersey City, N. J.

F. W. VOGT, Jos. T. Ryerson & Son, Inc., Jersey City, N. J.

*L. F. Coffin:* Large oil circulating systems require a high grade lubricant and one that will separate easily from water and dirt and of course, low viscosity oils do this more readily than the higher viscosity oils. Consequently we oppose at each step the use of the very heavy oils for system work and are opposed to the use of extreme pressure lubricant. In order to avoid use of such materials, however, manufacturers of steel mill machinery should furnish properly designed and hardened and ground and lapped gearing.

Mr. Hand's paper should serve as a challenge to steel plant engineers. Though many of the points brought out in this paper require that they be brought to the attention of the manufacturers of miscellaneous steel mill equipment, in the last analysis the responsibility for seeing that proper equipment is furnished, rests with the operating and maintenance men. Engineering departments today are most cooperative in giving us properly designed equipment. So that unless all of us, the millwright foreman, master mechanics and operating superintendents are awake to defects in equipment and present our wants to our engineering departments when new equipment is contemplated, we cannot hope to be sure that the manufacturers of such equipment will meet our real needs.

*S. J. Shavinsky:* Many who are concerned with that one phase of the lubrication problem—high pressure greasing—are of the opinion that the results tend to better themselves in direct proportion with the amount of grease used. Experience seems to indicate that this contention is fallacious. Within the realm of common sense, the direct opposite seems to be true—the less grease used, the more lucrative will be the results that follow:

The mere acceptance of this principle by the man in charge of lubrication means very little. The crux of the problem lies in the education of the men who actually do the greasing. This may mean the expending of a great deal of effort, but this effort will seem puny in comparison with the benefits to be derived, once these men learn that perfect bearing lubrication depends not on how much grease can be used but rather on how little grease can be used.

*F. O. Schnure:* I am sure we have all enjoyed Friend Charlie Hand's paper. I say "friend", advisidly, because he got up and said, "Members of the Association, and Gentlemen", the inference, of course, being obvious.

Part of the paper and discussion this evening has been centered on the lubrication problems of large units. Our electrical department concerns itself only with such when they are a part of the motor/generator set, or in some cases the reduction gear, where the motor and gear unit are maintained as a unit. Some years ago, when it became necessary to re-babbitt the 14″ x 42″ bearings on one of these units, the manufacturer's drawings were carefully followed with respect to the grooving in the bottom half of the bearing, the thought being that this should represent the best mechanical ideas of the builder. Nevertheless, trouble developed again and again and finally we resolved to pattern these bearings after the 50 ton flywheel bearing design on our large motor/generator sets. This design consisted of a plain surface with suitable champfered or recessed boring. It was a great improvement and raised the question in our minds, "Why had not the reduction gear builders, who should lead the way in matters of fundamental design, adopted the above design, which has operated so successfully on electrical machines for many years and which now seems favored for general use".

I have nothing further to add to Mr. Hand's paper. I can pick up the telephone and get an earfull of lubrication any day in the week—and he has even been known to come in the office and offer it. In fact, he finds us a little bit like the old German music teacher who had been having a little trouble with a pupil who persisted in singing a little off key. He said, "I blay de white keys, I blay de black keys and always you sing in de cracks".

*M. Reswick:* When I got the notice of the meeting for tonight I said to myself—it's about time somebody with wide-experience got up and called the attention of the machinery builders to some much desired improvements in designing for lubrication. Tonight as I was listening to Mr. Hand's paper, I became convinced that every statement he has made was just so, and it sort of reminded me of my own experience in the steel mills where I have gone through the very same experience in a somewhat modified form.

The outstanding point that I see in Mr. Hand's paper is that the suggested minor improvements in designing for lubrication can be made for just about one-hundredth, or perhaps one-thousandths of the cost in making the same improvements after the machinery is set in place.

*G. C. Pfeffer:* I certainly enjoyed Mr. Hand's paper. I think there is a lot in what he said in designing for lubrication, especially as applied to motors. Our experience with motors has been that the majority of the bearings are not designed to relieve the bearing of the surplus oil, with the result that a good bit of trouble is experienced with commutators. I think if the motor manufacturers would give that some thought, we would rid ourselves of a lot of trouble.

*W. G. McDonald:* I can answer Mr. Pfeffer's question with regard to oil leaking along the shaft of the bearings. I think that Mr. Pfeffer will realize, as well as most other operating men, that the motor manufacturers have recognized this problem and in the last five to ten years at least there has been a real improvement in bearings. That goes for all manufacturers without exception. They have redesigned their bearing housings to the point of preventing the escape of lubricants into the motor and out on to the floor. They have equalized air pressures within the reservoir to prevent any suction of the oil out of the bearing housings and, in general, I think there is not very much room for improvement in the sleeve bearings that are being built into our modern general-purpose motors today.

Now with some of the old motors, there is real room for improvement. It is almost impossible to keep the lubricants in them, but I know many cases, of our S.K. Motors and C.S. motors, equipped with sealed sleeve bearings, that they have been in use for a number of years with entire satisfaction. I will say we have run them ourselves before ever offering them to our customers, for as much as eighteen months, without ever adding a drop of oil, and I think that holds true pretty much of the modern motors that are being built today.

Now with the old motors, from fifteen to twenty years old, there is a lot of room for complaint and, unfortunately, our customers have too many of the old motors on hand.

*W. S. Wagner:* We nearly always omit selling lubrication to the man on the job. It is too often true, that the equipment is purchased solely through the engineer or operator and no consideration is given to the maintenance men who have to keep the equipment in condition. When equipment is installed, the person in charge just says "Oil that machine." If he would put a little more human nature into it, I think our lubrication problems would be more nearly solved. A little more cooperation with the manufacturer, telling him what we want, and then when we get out in the field, telling the man who is doing the actual oiling what we want done there, would be time well spent.

*D. L. Sasser:* Well gentlemen, I want to say this, that in my capacity as chief lubricating engineer, I

get all the complaints. We are told that the customer is always right, and I always thought that in a failure of a bearing, gear pinion or anything else, it was the oil—didn't think it could be caused by anything else. It is very unusual to hear a discussion of this kind and it is very much appreciated.

*E. S. Glauch:* Mr. Chairman and Gentlemen: I happen to be in the lubricating business at the present time but for about 17 years prior to that the writer was engaged in the design, manufacture and maintenance of equipment.

I might state that having been a designer of equipment, one of the last things to be thought about at that time was lubrication. When we designed a machine or an engine, as I had been in the engine business for many years, also with manufacturers of rolling mill machinery, we would design a machine and then after the machine was designed we would then consider lubrication, locate oil holes or make provision for grease cups.

I have noticed, however, in the last five or ten years considerable change has taken place in the design of equipment, that is, consideration of the lubrication is given in order that better lubrication is provided.

After having been connected with concerns who manufactured engines and machines for resale, the writer spent several years as plant engineer for one of the smaller steel companies and encountered some of the very things that Mr. Hand has spoken about tonight.

In the last eight or nine years, I have been in the lubrication business and have run into many conditions such as mentioned by Mr. Hand. In other words, a user might have some difficulty that appears on the surface to be lubrication trouble,—the lubricant may be our own or a competitor's, and the first thing they think about when such conditions arise is that the trouble is due to the lubricant. In many cases investigation discloses the fact that it is not the fault of the lubricant that they are having trouble but the provisions for lubrication or application of the wrong lubricant and in some cases the unit is even too small to carry the load that is imposed upon it.

I remember one case in particular where there was a worm gear drive which was not in a steel plant but in a chemical plant where they were having trouble.

This particular worm drive was on a machine known as a crystallizer and in this particular operation the material when first put into the machine was in liquid form and the amount of power to drive the screw type agitator in the bath was not as great as the power required after the material started to crystallize. There was a comparatively small worm gear unit on this drive and they originally lubricated it with light oils and then went to cylinder oil and still were having trouble. The gear box would heat up and the worm wheels would cut and would have to be replaced at comparatively short intervals.

Our company was called in on this particular job and as we could not correct the mechanical defect or change the size of the worm gear unit, the only thing we could do was to provide a lubricant heavier in consistency than what they had been using and loaded with a considerable percentage of graphite. In this case, the heavier lubricant containing a considerable percentage of graphite increased the life of the unit, that is, the worm wheels did not have to be replaced at such short intervals, also the heat in the gear box was cut down and the lubricant itself did not have to be replenished as often as with the lighter lubricant. As stated above, we cannot correct mechanical difficulties with a lubricant, even though in some cases the change in lubricant will reduce maintenance cost. Another thing that occurred within the last month in our own plant—a small machine was designed for a special job, we being manufacturers of quite a variety of products, such as pencils, motor brushes, paints, rubber and brass goods, also lubricants, which require special machines which cannot be purchased on the open market. One of our designers designed this machine and it was built by a jobbing shop and sent to us. After this machine was delivered to us the writer had occasion to inspect it and naturally the first thing he noticed was that no particular provision had been made for lubrication of the bearings that carried the spindle, which spindle was to operate at a speed of 3500 RPM and over. The bearings were, of course, anti-friction. The writer did notice that an oil hole had been provided in the top of each bearing housing but no oil cup had been installed. He asked the Foreman under whose supervision this machine was to operate how he was going to take care of lubrication. He looked at the machine and stated there was provision for an oil cup. The writer immediately advised him that if the ordinary type of oil cup was installed it would not be long before the bearing would be completely filled with oil and operating at the speed at which this machine was to run the bearings would heat.

The writer suggested to him that he take this matter up with the designer of the machine and ask him just how he was going to take care of lubrication. Taking this matter up with the designer, he was advised that was simple—to install an oil cup and feed oil. The Foreman was not satisfied with this and kept after both the designer and the Maintenance Department who was installing the machine until they decided it was best to install some special oil cups which would maintain a constant level.

Before this change was made the machine was erected and started for a trial run. One of the maintenance crew who installed the machine used an oil can for putting oil into the bearings and the foreman advised him not to fill it up but found that the mechanic was still putting oil in after he was supposed to stop.

The next day when the bearings were dismantled in order that they could be taken to the machine shop so as to loacate holes for the new oil cups it was found that at the bottom of the bearing housing a drain hole had been provided but these holes were inaccessible and apparently nobody knew they were there. It can readily be seen, therefore, that any oil that would have been fed into the bearings with the regular type of drip oil cup would have run out of the bottom of the bearing and the bearing would not have had proper lubrication and after a few days' operation there would have been considerable oil dripping on the floor. If the writer had not called the foreman's attention to this matter of lubrication undoubtedly this machine would have been put into regular service and possibly before conditions could have been changed or remedied, a set of bearings would have been ruined.

In the writer's contact with steel mills and other plants during the last eight or nine years, he has run into other cases of this type where improper provision for lubrication exists or the improper lubricant is used in that the supplier of the lubricant was not consulted as to the proper type of lubricant to use for a particular job.

Another case that came to the writer's attention about a week ago, was where a company had been using one of our products for at least four years for jobs lubricating fine wire. In this particular operation the lubricant was applied to the wire in order that the formed parts could be removed from the mandrel without stretching. This concern had used this particular lubricant, as stated above, for approximately four years. Just why or how they ever decided to use that particular product is not known, but after four years of operation with this lubricant they found that they were getting rejects when the product was finished and finally traced the trouble due to the lubricant in that after the part was formed they were put through a firing operation and if all the lubricant was not burned off in this firing operation it was apt to effect the finished product. As stated above, after four years of use of one lubricant they then called in the supplier of the lubricant for their recommendation.

Therefore, it appears to the writer that Mr. Hand's paper is a good starting point to improve conditions existing at the present time in many plants. He has brought out some very definite points where trouble exists where the machinery builder must make changes and improvements in order that the operation of the equipment can provide proper lubrication. He further has brought out that there must be cooperation between the plant lubricating engineer and the operating department and the supplier of the lubricant. The writer wishes to state that if all parties concerned follow some of Mr. Hand's suggestions, in a few years from now plant lubricating engineers' troubles will be considerably less than they are today and the maintenance cost will be considerably less and the rate of production can be maintained at a more uniform and increased level. This also would tend to reduce production costs.

*F. W. Vogt:* While Mr. Hand, in speaking of designing for lubrication had in mind such lubricants as oil and grease, his remarks apply, I believe, equally well to water as a lubricant on composition bearings. Many of the initial failures on this type of bearing have been due to improper bearing design and arrangement of water supply.

Generally speaking the arc of bearing contact has been too great and much better results are being obtained when reduced to approximately 110 to 135 degrees. The lower coefficient of friction of water lubricated composition bearings in comparison to ordinary grease or oil lubricated metallic bearings lessens the tendency of the roll neck to climb out of the bearing and makes unnecessary 150 to 165 degree bearings as are still frequently found in use.

In designing composition bearings it is well to keep in mind that the bearing itself is an insulator and therefore all frictional heat must be directly removed from the roll neck. This is best accomplished by first, designing the bearing so that ample area of roll neck is exposed or free from the bearing; and secondly, by directing the supply of water on to this exposed part of the roll neck to get the maximum cooling effect possible.

Automatic grease lubricating systems no doubt make possible increased life of metallic bearings and also their maximum operating efficiency because of the fact that the condition of lubrication is made most nearly uniform. When, however, composition bearings are used and water only needed as a lubricant, this same *uniform condition* of lubrication can usually be easily and economically created by the use of spray pipes or nozzles. Proper and adequate water supply to composition bearings is one of the most important factors in obtaining the long bearing life and attractive power savings that are possible.

Scale and grit in any bearing will cause plenty of trouble and composition bearings are no exception. This foreign matter will either embed itself in the composition material and score the neck or be carried on around the bearing leaving scratches in it. If this condition is permitted to exist, the high polish on both the roll neck and bearing which is normally the result of clean operating conditions, is destroyed. The result is an increase in power consumption and rapid wear on the bearing and roll neck. Guards to keep this foreign matter out of the bearing are not new, by any means, but perhaps are more important on composition bearing installations than on babbitt or bronze.

In designing for lubrication of new equipment using composition bearings many operating headaches can be avoided by making bearings as nearly 120 degrees as conditions will permit, leaving plenty of roll neck surface exposed for cooling sprays, and providing a convenient and efficient protection from scale and grit.

# DISCUSSION

## PITTSBURGH SECTION

PRESENTED BY


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*H. S. Page:* This paper indicates that the writer has an excellent understanding of the fundamental principles of bearing design which must be adhered to in order to obtain successful performance.

A bearing, particularly of the sleeve type, may be considered as a pump which picks up the lubricant in the lower pressure area and establishes an oil film which is carried to the higher pressure section. Thus it is necessary to determine the location of the low pressure area in order that an ample supply of lubricant may reach the right spot, with the aid of distributing grooves well-chamfered.

Within the low pressure area there may be a very positive suction which is sometimes utilized to lift oil several inches from the reservoir below. A case in mind is that of a 2000 horsepower, 250/500 RPM mill motor operating in the Pittsburgh district. In this instance, the oil rings were removed from a standard bearing and suction tubes inserted for conveying the oil up to the bearing surfaces. These bearings have been operating successfully without attention of any kind for the past four years.

Many of the causes for bearing failures listed by Mr. Hand have been experienced in the development of large motors and generators by the builders of electrical machinery who use ring-oiled bearings. While a lead base babbitt is generally satisfactory on small bearings, there is a decided preference for the tin base metal for large bearings even where there is no impact in the load. The present tendency to reduce the size of bearings and employ higher unit pressures will increase the use of the hard babbitt having something like 84% tin, 8% copper, and 8% antimony. Best results can be obtained with a liberal number of machined dovetail anchorage grooves. The cost of the extra machine work is justified by some saving in the volume of expensive babbitt, and a nice clean surface insures a much better contact than a rough casting with large cored recesses.

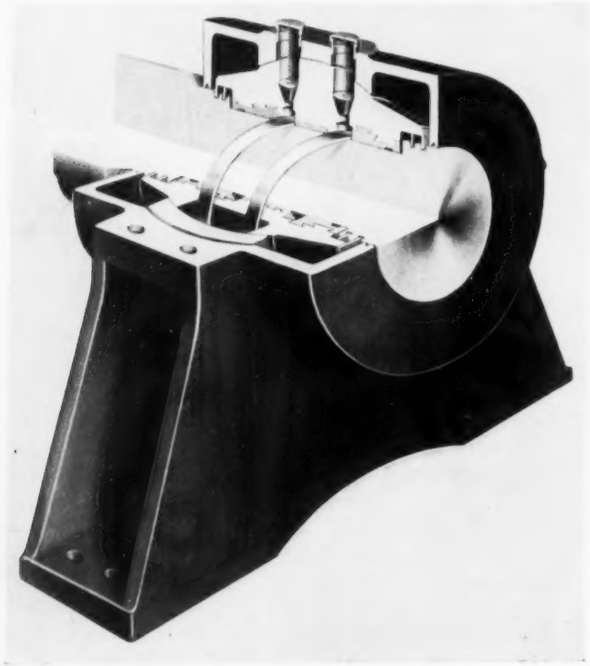
When a bearing fails repeatedly, one should not assume immediately that the bearing is too small. A comparatively short bearing will carry a much greater load than most people are aware of provided the journal, babbitt, and oil are in good condition. It is generally known that a very little grit is fatal to antifriction bearings and if the same protection is given oil film bearings they will carry very much heavier loads than has been common practice.

Fancy oil grooves in the part of the bearing carrying load have been discarded as detrimental to the maintenance of a high pressure oil film. For loads in a downward direction on ring-oiled bearings a liberal chamfer along the sides is all that is needed to distribute the oil from the rings.

It is our experience that the operation of oil rings of rectangular, trapezoidal or tee cross-section at any speed is greatly improved by a slight crown on the inside surface. A ring having a flat surface against the shaft is likely to continue to swing like a pendulum after the motion is once started, riding first on one edge and then on the other. Also a ring with a flat surface on the shaft will slip easier because for a given weight of ring a thicker oil film will be established under it than under a ring with a crowned surface which tends to break through the film and turn faster. Rings of rectangular cross-section running in slots with parallel sides will often hug to one side and the drag of the oil film between the ring and side of the slot will reduce the speed. A guide at the top to hold the ring in the center of the slot will stop this particular trouble. Some recent changes in the material and shape of tee rings has led to greatly improved service for this type of ring which is considered the simplest and most satisfactory for general use. The joint plates on the sides of the vertical leg of the tee will not catch in the slots or retard appreciably the velocity of the ring through the oil.

The time has come when sealing of the lubricant against leakage from the bearing housing must be practically a 100% job to make a motor acceptable to the purchaser. For best service seals should not be subject to wear which will require frequent replacing. One method of construction for a spherical seated ring-oiled bearing with adequate protection against leakage of oil or oil vapor is shown on the accompanying illustration, Figure A. This particular design followed an investigation which showed that most of the oil leakage from bearing housings was due to oil vapor formed in the ring slots. By dividing the ball seat on the lower half of the bearings the rings were

enclosed so that no vapor could escape to the space between the bearing shell and the outside housing. Drain grooves are put in the babbitt near the ends of the bearing to catch most of the end leakage. Beyond the end of the babbitted surface are two more catchers formed by oil slingers turned on the shaft and close-fitting stationary plates held in the bearing shell. In case the bearing is located in a strong draft which would tend to suck the oil out of one end, this suction can be stopped by adding an auxiliary baffle plate on the outside of the housing.



**(Fig. A)—Pedestal and bearing to eliminate oil leakage.**

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*F. J. Thomas:* It is not often that we have the pleasure of hearing such a paper as has just been presented. Mr. Hand has pointed out but a few of the difficulties which maintenance men experience in trying to keep their mills properly lubricated.

I was pleased to hear Mr. Hand and Mr. Page criticize grooves in bottom halves of large drive bearings. It is still necessary to discourage this practice of cutting fancy grooves which are admired so by many old timers.

The proper sealing of bearings is important if oil and grease losses are to be eliminated. Bearing life may be increased by effective sealing. Manufacturers have still much to do before we will be able to do without numerous men now employed in keeping oil and grease flowing into bearings and gear cases.

The improper mesh and lining up of gears and pinions still is a source of trouble to maintenance men. New teeth often start to wear along a thin line or over only a part of the length of the tooth. In many cases wear takes place until a suitable tooth bearing surface is reached. In the meantime much pulling and gripping of the metal takes place. Sometimes extreme pressure lubricants are used to prevent wear from occurring too rapidly. Proper machining and lining up of geared units will help the maintenance men considerably.

Machine builders should pay as much attention to the smaller details as they now pay to the important ones. It should not be necessary to install homemade oiling devices in a great hurry to properly lubricate points overlooked in the original design. Yet this is what often happens. A small, apparently unimportant bearing will cause delays in a mill if it is burnt out.

Much labor saving machinery is being put into use today. Such equipment should not require extra men to oil and grease it, and if provision is made in the original design for efficient, easy (and oftentimes automatic) lubrication, this will react to the benefit of machine builders as well as the steel companies.

Our engineering departments are not wholly blameless and are not always sufficiently aware of the need for these things. Much of the improvement in the design of mill machinery can be traced to mechanical and electrical men calling the attention of engineering departments and manufacturers' representatives to defects. These maintenance men are always suggesting improvements which later become incorporated in newer equipment. I sometimes think it would pay manufacturers to have a man to go around picking these things up so that improvements could be made much sooner than is now the case.

When Mr. Hand spoke of the heat treating of gears, perhaps he had in mind the hard surfacing of shafts, pins and bushings, as well. Heat treating, nitriding, carburizing and other methods of hard surfacing are increasing the life of various parts as much as tenfold.

Speaking of leakage from oil-ring bearings, many people find it hard to realize that the lower the oil level can be carried, the less leakage will occur. There are some devices now available which will maintain oil levels at a constant height. We find that excellent results are obtained by maintaining the oil level at twice the thickness of the oil ring above the bottom of the oil ring.

When equipping mills with oil circulating systems, the piping should be placed where it can be seen and inspected, and easily accessible to be worked on. It should not be buried under floors or where scale may cover it. Some systems have been installed so that the piping may not have been seen for ten years or more. Perhaps the mill people have been adding five to ten barrels of oil month after month, and someone finally begins to wonder where it is going—does it evaporate, wear out, or what? No, it can only leak away through deteriorated piping, loose joints or leaking tanks.

With all piping in the open, frequent inspections are easy and will keep leakage down to a minimum. Of course, this will make the oil companies look for new markets.

We all realize that Mr. Hand could have talked all afternoon, and all night, too, for that matter without exhausting his subject. I do not want to get started either. But the point is that if this question of proper design for proper and efficient lubrication is given more serious thought by the manufacturers and our own engineering departments, not only the mainte-

nance men, but also the machine builders themselves will benefit. Proper lubrication can be designed into mill machinery.

*L. M. Nesselbush:* You either have to oil the bearing or wear it. The oil flow is the answer to the bearing problem. I think that is the only reason that the roller bearing is on the market today, because in years past you chucked a piece of grease in the general direction of the mill and considered that the bearing was lubricated. I am certainly very glad to know you are taking this interest in the matter of lubrication.

*P. G. Lessmann:* The speaker has referred to the advances made in designs of machinery with respect to lubrication which have been made by certain groups of manufacturers, and the lack of such advances shown by other groups, especially the suppliers of miscellaneous mill machinery. Among the latter we would suspect to be the manufacturers of electrical machinery, but I believe that without being immodest, the manufacturers of electrical machinery can count themselves to belong to the first group. Electrical machinery naturally does not involve such a large variety of problems in lubrication, but what it involves has been solved to the satisfaction of everybody.

Now after all, discussion about lubrication always comes back to three factors which must be considered in judging any lubricating problem. These are:

1. Speed
2. Pressure.
3. Temperature

The problems encountered in electrical machinery naturally cover only a certain range of the speed—pressure—temperature field. The lubrication problems in mill machinery covers another range or they may in part overlap. I believe, therefore, that it may be beneficial if the problems encountered in electrical machinery are stated briefly and at first stripped of all their outward complexity. Electrical machinery covers speeds ranging from very low speeds to the highest encountered in commercial apparatus—i.e., from around 20 ft./min. to around 3500 ft./min. Pressures range up to medium values—i.e., 200 pounds per sq. in. for sleeve bearings and 400 pounds per sq. in. for shoe type bearings. The temperature ranges only in the low values—i.e., up to about 100°C. It can be seen right here that the range in steel mill equipment may shift to the other end of this scale—i.e., there will be mostly low speeds, but high pressures and high temperatures. The temperature problem actually is the most important one. The electrical manufacturers strive to keep the temperatures around well defined points; for instance, the temperature rise of any bearing is not to exceed 35°C. with a maximum ambient temperature of 50°. This restriction actually has benefitted the designer enormously. The temperature of the bearings is determined by the balance between friction losses and heat carried away by the cooling surfaces. The friction losses are a function of the design of the bearing, the oil used, and the pressures and speeds at which the bearings are run. The oil used should be always very nearly the same, since the temperature is so restricted. A certain balance between friction losses and heat carried away must then always be struck so as not to exceed the limit of temperature. This can be done by various means. If the bearing was originally a full sleeve bearing, but only one directional load is carried by it at all times, the losses can be materially decreased by relieving the half which does not carry the load. It sometimes is possible also to increase the clearance which can safely be done to astoundingly large values, and thereby also decrease the frictional losses. A decrease in the length of the bearing will also reduce the frictional losses provided the decrease in length does not increase pressure excessively or cannot be effected for other reasons. The temperature can be kept down by increased convection, keeping the bearings well ventilated or even directing an air blast against them; or by increasing the flow of oil over the shaft journal or by even circulating and cooling the oil or finally by water cooling the bearing or shaft journal, taking care that water and oil circuits are kept separate and no water leaks out into the oil chamber or even the journal.

The flow of oil frequently can be increased by observing that the oil ring is freed from restrictions in its motion. Oil rings if allowed to run close to a flat surface will invariably stick or drag. They should be kept away from such surfaces by a few guide pins or bars which allow them to rotate freely and with the least amount of friction. The submersion of the ring has comparatively little influence on the volume of oil delivered by the ring, provided the ring can rotate freely. The speed, of course, is affected.

All these means of checking the temperature have actually been employed very successfully. Naturally such means are predicated on an otherwise reasonable design of a bearing. Oil entry grooves or pockets, finish of journal and bearing, and alignment of bearings must all be taken care of before other adjustments are made. The material of the bearing, aside from a strength standpoint, is not of extreme importance, but should be of fair heat conductivity and reasonable density.

If we turn to the lubrication problems presented by the various pieces of machinery used in a steel mill, we may at first be amazed by their apparent multiplicity. A closer analysis, however, will reveal that they all can be dealt with on the general basis of the three main factors enumerated previously—speed, pressure, temperature—which very definitely put them into certain categories. High speed bearings should use oils of low viscosity; low speed bearings, oil of high viscosity. Low pressures would require light oil; also high pressures at high speeds. High pressures at low speeds, however, would require heavy oils. As to temperatures, a distinction must be made between the temperature of a bearing in disposing of its own losses and the temperatures to which it may be exposed. The first can in most cases be controlled by means described previously. The latter will have an influence on the design of the bearing in such a manner that the bearing must receive additional cooling or must be removed from the source of heat sufficiently to secure adequate lubrication. If a bearing is exposed to too much heat, adequate lubrication may become impossible.

While manufacturers and buyers of mill equipment undoubtedly are making progress in their ideas about

designs for adequate lubrication, the points brought out may be helpful to the steel mill men in analyzing the existing problems and finding a solution for them. Mr. Hand has shown us a number of very good examples which were essentially based on an analysis along the lines which I endeavored to draw.

*J. A. Burg:* Mr. Hand is to be complimented on his timely and interesting paper. Many of the problems he has had are familiar to all of us.

In the past, the main idea in designing mill equipment seemed to be to make it heavy enough. As an old professor of mine told his class, the fits used in a steel mill are like a rat's tail in a barrel. We have been getting away from that idea for the last few years and today proper design and proper selection of materials is given more consideration. In selecting brass or steel, we usually specify the analysis and physical properties required and the results obtained have proved that this is proper.

In our own plant, failure of certain armature shafts has been practically eliminated by the use of special nickel alloy steels. On some of our cranes where the track wheel bearing pressure was high and the runs long, difficulty was experienced in properly lubricating the bearings. Heavy greases and oils were used, the oil box re-designed, but still the bearings ran hot and wore out rapidly. The track wheel pins also scored badly. Replacement of the track wheel pins with nitrided steel eliminated practically all of our troubles on these cranes.

On other shafting, we have had trouble with the brass bearings wearing out and the shaft journals scoring. The chromium plating of the shaft journals eliminated our troubles here.

We have found on some of our older equipment, the life of our bearings has been very good and the reason for it in most cases is that the bearings were liberally designed, the bearing pressure being kept low. The use of high bearing pressures leads to difficulty in lubrication and increased wear.

The use of special felts in the oil boxes of cranes has proven very satisfactory in many cases.

One of the crane builders has developed a solid brass bearing so designed as to provide an oil reservoir and sealed to keep the oil in. We have used some of these with very satisfactory results.

The enclosure of gearing in oil-tight cases has increased its life considerably.

A big problem today is the reduction of maintenance costs and, as Mr. Hand pointed out, much can be done along this line by good design.

*M. Reswick:* About a month ago I had the privilege of visiting the Sparrows Point plant of the Bethlehem Steel Corporation, and I was much impressed with the improvements in lubrication practice made by Mr. Hand. I have observed the operation of the equipment described in this paper together with other improvements on machinery not mentioned in Mr. Hand's paper. Lubrication is, indeed, reduced to an art and a science at this plant. I am confident that the improvements pointed out will be incorporated by machinery builders on new equipment.

*J. H. Schenck:* I want to thank Mr. Hand for his attitude on bearing troubles in steel mills. We hear of so many cases where every time something happens to a bearing, they want to change the oil. That is also the case with gears. My lubrication principle is that as long as you are getting oil into the point of contact you will get lubrication, and it is usually a question of misaligned bearings, tooth form or something like that causing the trouble.

In regard to lubrication; I was interested in Mr. Hand's remark on the gears which were lubricated by both bath and pressure feed, without experiencing leakage at the pinion bearing. Was the oil also fed to point of contact of the gears under pressure?

*C. R. Hand:* Pressure spread to the gears. Our Nos. 1, 2, 3, and 5 mills are slow speed. Occasionally the mill started without oil pressures being carried on and we can run the mills without pulling. Even then we get quite considerable leakage due to the fit of the bearing or cap on housing and we got a slight oozing out.

*J. S. Schenck:* An idea occurs to me about circulating systems, I noticed one gentleman said if equipment were properly designed there need not be much concern about type of lubricant. That used to be true, but when operating these circulating systems on large machines where you use good seals, it is important to have a grade of oil that resists oxidation, and separates readily from water; that is, for economical operation.

*H. K. Siefers:* I wish to congratulate Mr. Hand on his paper and to thank him for taking a little of the load off the shoulders of the oil people, because the customary thing is to blame either the oil man or blame the oil. I think one thing that the operators might remember is something I have heard quite often, that "a bearing has never failed that had oil on it." Of course, that does not mean on the outside, but if they get the oil to the proper part, the bearing won't fail. Unfortunately, due either to dirt or design of the bearing the oil does not get to the proper point in many cases.

*L. R. Foust:* Making bearings tight I think will help out the lubrication of bearings more than any one thing. Also making oil tight bearings will permit use of oil instead of grease for lubrication of bearings for which oil is a better recommendation. This also permits the use of higher grade oils because they will stay on the bearings.

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# THE OXY-ACETYLENE PROCESS

## ITS USE IN THE IRON AND STEEL INDUSTRY

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▲ AMONG the divisions of the oxy-acetylene process employed in the iron and steel industry, none enters more widely into all phases of steel manufacturing and distribution than flame cutting. From tapping furnaces and cropping ingots to the cutting of finished steel to shape, flame cutting is recognized as an indispensable tool. Recent trends and developments are pointing toward even greater utilization of this cutting method. There are not only new possibilities for economies and improved quality in steel manufacturing, but many opportunities to widen the market for steel in the form of heavy plates and shapes, especially for welded construction.

A notable advancement in which oxy-acetylene cutting is an essential step in making steel with wing type ingots. In these, segregated and piped regions occur in the central portion which remains as scrap when the three wings are removed by flame cutting. It is claimed that the wings are superior to ingots made by former methods, and that the discard does not represent extra expense when it is considered that it does not go through the rolling or forging process before being cut off.

The practicability of the wing type ingot is entirely dependent upon the ability to sever the wings by flame cutting, economically and at a high temperature. The temperature of the ingot when cut is in the neighborhood of 1450 deg. This is very economical from the point of view of oxygen consumption and necessary in the case of high carbon and alloy steels in order that there be no surface cracking upon cooling. Water-cooled cutting blowpipes are available for this high temperature cutting, and have made the job a practical one from the standpoint of steady production. The actual time for cutting a wing approximately 1 ft. thick by 5 ft. long is 7 min., about twice the speed of cutting steel cold.

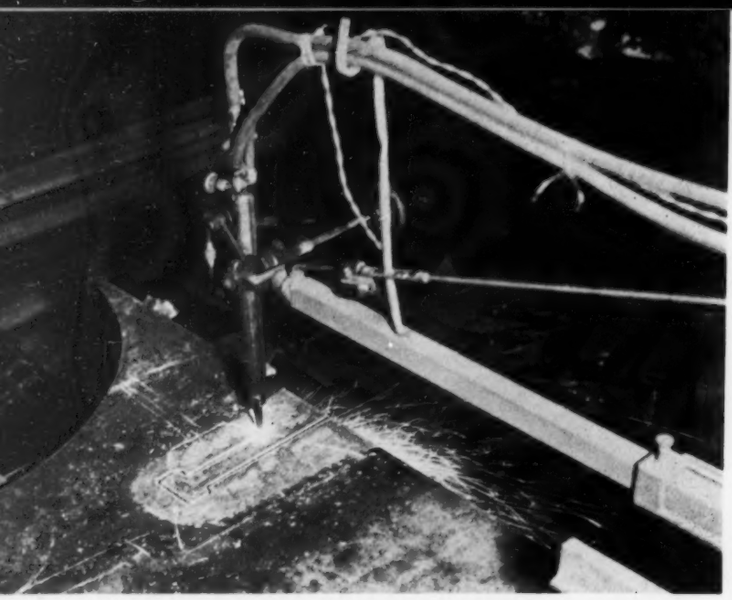
There are other possibilities for effecting economies in the steel mill by cutting metal at red heat, and the knowledge gained in cutting wing type ingots is proving most useful.

Numerous uses of rolled steel require a method of cutting the material to length or shape that is accurate, flexible, and does not harm the edges cut. Oxy-acetylene cutting has met this need for customary uses of steel, and also has made possible a vast expansion in the market for rolled shapes and plates by creating for them new utility through the infinite variety of forms into which they may be cut.

The accuracy of commercial machine flame cutting is such that, except where a machined edge or surface is needed, further treatment of the cut is unnecessary. It has been shown that where the cutting blow-pipe is guided with precise smoothness and accuracy the variation from squareness in straight line cuts will be no more than 0.0030 in. for 1 in. material, 0.010 in. for 2 in. material, 0.0175 in. for 4 in. material and 0.0312 in. for 6 in. material. This degree of precision requires of course that such variables as the size and disposition of heating flames, size of cutting oxygen orifice, pressure of cutting oxygen and rate of travel be coordinated for a given condition and thickness of cutting. The trueness of flame cutting is thus a valuable factor in enlarging the field for shape cut steel.

To the average person acquainted with oxy-acetylene cutting, the high degree of flexibility probably represents its most important characteristic. Certainly everyone in the metal working industry is familiar with the jig-saw ease of shape cutting, the range in thickness which can be successfully severed, and the portability of the equipment when it is desired to do the cutting in place. All this, too, has proved a boon to the use of shape cut steel in the fabrication of machine parts, jigs, frames and bases—an important and constantly growing outlet for products of the steel mill.

Constant attention and study must be given to the adaptation of flame cutting, however, if this field is to be kept expanding at the present rate. Several instances of the unusual adaptability of oxy-acetylene machine cutting show what can be accomplished with a certain amount of ingenuity in doing a good, econnomical job of cutting steel. In one instance, the cast steel plows for a number of new agitators shipped to a chemical plant were found to be considerably larger than could be accommodated by the housings. Urgent need for the equipment made it inadvisable to disassemble the plows for machining if some means could be found to cut them down accurately and at less expense. Although flame cutting was thought of at once as a possible means for doing the job, it was realized that some out of the ordinary procedure for doing the cutting would have to be devised since it was necessary that the cuts be smooth and curved as well, and to a definite tolerance so there would be proper clearance in the housing.



(Fig. 1)—Cutting blank for a 1½" bolt.

After some study, it was decided that a successful job could be done with a portable, self-propelling cutting machine which was available. A special plate which fitted the outside curve of the plows, corresponding to the mixer shell, was first rolled to the proper radius. On this were tack-welded guide rails for the machine which not only followed the outward curve but also the diagonally downward direction of the plows themselves. With the blowpipe head set at the correct angle, it was then possible to make smooth, accurate cuts one right after the other. About 12 cuts per hour were completed. This involved time for setting up the curved plate, machine, and doing the cutting. Altogether, 450 plows were trimmed in this manner at an estimated saving of $4,000.

Another unusual problem was presented in trimming and beveling ready for welding, heavy curved plates required for branch outlets in Boulder Dam penstocks. The plates, ranging in thickness from 2¼ to 4¼ in., were first flame cut to approximate shape, and then formed in special presses to the curved shapes required in fabricating the outlets. Trimming of the curved plates to final size, giving the edges a slight bevel at the same time, was the rather intricate job required of flame cutting. Because the plates were curved or dished, regulation portable self-propelling cutting machines would not give the true radial cut required due to the fact that only three of the four wheels could be in contact with the plate at any one time, throwing the machine out of line no matter what combination of three wheels might be touching.

The solution of course was to provide correct three-point suspension. A templet in the form of a small round rod was tack-welded to the plate continuously near the line of the cut for two grooved wheels of the machine to run along. A third wheel was provided on the opposite side of the machine in line with the blowpipe, keeping it perpendicular to the plate as curvature changed, except for a slight deviation from perpendicular required for the bevel.

The effect of flame cutting on cut surfaces has been a subject of discussion and investigation for a good many years. It was early appreciated in the steel industry that the action of cutting on low carbon steel was beneficial compared with other cutting methods commonly employed. The users of steel were inclined to believe otherwise and have only become convinced of the actual facts after repeated demonstrations and tests. Restrictions on flame cutting naturally tended to restrict somewhat the use of rolled steel—at least tended to make it more expensive to fabricate.

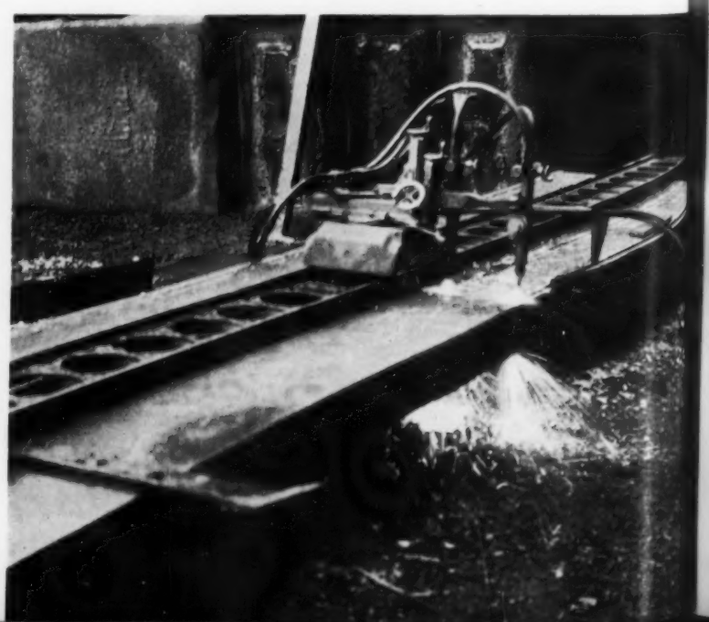
A recent revision of the A.S.M.E. Boiler Code, it is felt will go far toward removing other restrictions remaining on the flame cutting of low carbon steel. The revision is in the form of two sentences added to paragraphs Nos. P-104 and U-72. The revised paragraphs now read as follows: "The plates may be cut to size and shape by machining or shearing, or by flame cutting if the carbon content does not exceed 0.35 per cent. If shaped by flame cutting, the edges must be uniform and smooth and must be freed of all loose scale and slag accumulations before welding. The discoloration which may remain on the flame cut surface is not considered to be detrimental oxidation".

It should be explained that flame cutting was not prohibited in the Code but that it was generally held necessary to remove the surface of the cut so as to expose bright steel. This confusion is now done away with. A similar revision has also been put into effect for the A.P.I.—A.S.M.E. Unfired Pressure Vessel Code. It will now be possible for boiler and pressure vessel fabricators to use flame cutting in preparing joints for welding without the expense and delay of going over the cut edges a second time.

A recent investigation* as to the effect of cutting on structural steel should also go a long way in removing any restrictions remaining in this field. This was a comparative study of the effects on the metal of cutting by friction saw, shear, manual flame cutting and machine flame cutting—all methods in common use for structural steel fabrication. Tests were made to learn the influence of these cutting

* "Cutting Structural Steel," by J. H. Zimmerman, MECHANICAL ENGINEERING, July, 1935.

(Fig. 2)—Making narrow slabs, 8 in. wide, 6 in. thick and 14 ft. long.



methods on hardness, structure, toughness and ductility of the structural steel plate tested. In general the tests showed, as quoted from the article:

"1. The disturbance of the hardness and structure of the structural steel plate tested is less severe in flame cutting than in either shearing or friction sawing.

"2. Machine flame cutting does not appreciably affect the toughness of the metal adjacent to the cut surface, hand torch cutting definitely improves the toughness of this metal, and shearing or friction sawing decreases the toughness slightly.

"3. Ductility of the structural plate tested, as determined by the cold bend test, is less seriously affected by hand torch cutting than by either shearing or friction sawing. Machine flame cutting may even be beneficial in this respect".

In the marketing of rolled steel, especially heavy plate and slabs, there exists a definite trend toward selling the fabricator not just a rectangular piece of steel, but a piece flame cut to a given outline, simple or complex in shape. This not only saves freight on unnecessary steel to the user's plant and charges on scrap coming back, but is a service to the fabricator as well. Often the willingness to supply a piece of steel cut to shape means that rolled steel will be used in preference to other materials.

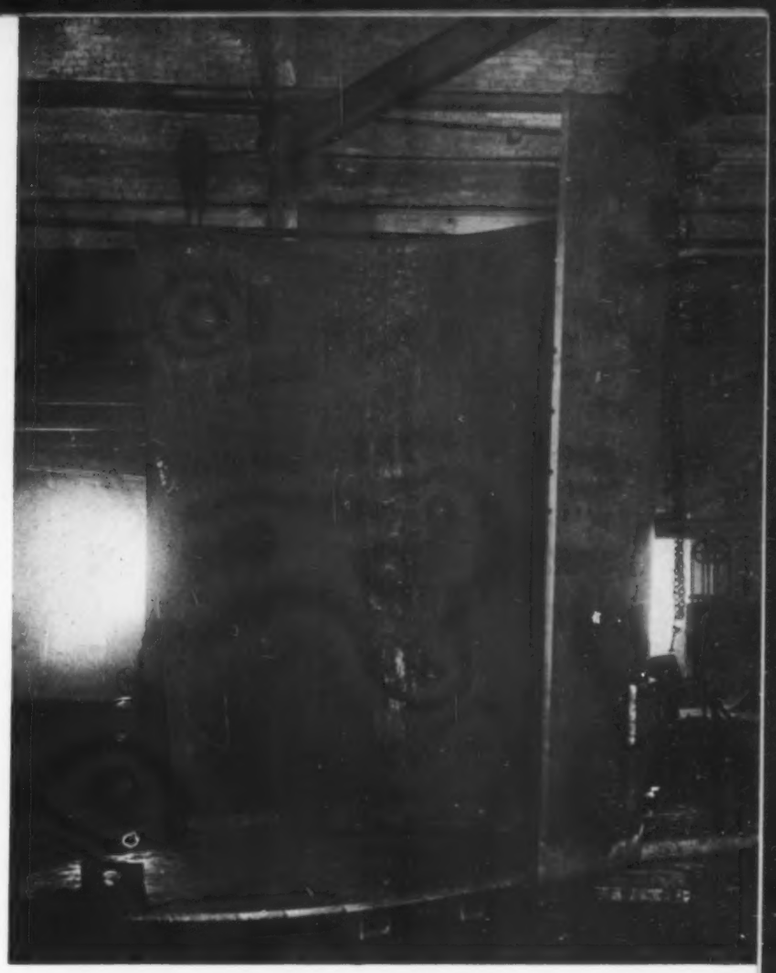
Saving in freight was a considerable item in the case of an order a steel mill received for parts for two rotors, each to be 12 in. in thickness and 4 ft. 8¾ in. in diameter. The rotors were each made up in two halves, so there were four blanks to be cut the same size and shape. Two operators did the job on a shape cutting machine in about 24 working hours, cutting the blanks out of two stock steel slabs weighing 54,000 lb. together.

Maintenance work in steel mills has been found to be an excellent outlet for rolled steel from which parts are flame cut to shape. Broken machine sections can frequently be replaced with rolled steel parts at less expense and loss of productive time than by any other means. Alteration jobs can be handled likewise and many routine replacement parts can be cut from steel as a regular part of the day's work. Scrap pieces otherwise destined for melting are frequently utilized.

A typical routine job in one mill was flame cutting seven wrenches for a cold strip mill from 4 in. steel plate. The wrenches measured 25 in. by 7 in. over-all and had a 2¼ in. hole cut in the large end. In another instance six 1½ in. bolts, 12 in. long were needed quickly to restore certain steel mill equipment to productive use. Square blanks for the six bolts were cut from scrap plate in about a half hour's time and sent to the machine shop for turning down and threading.

An outstanding example of quick work with the shape cutting machine in avoiding a prolonged shutdown occurred when a large compressor flywheel failed in service. In 13 hours' time, two halves of a replacement flywheel were cut from a 9½ in. rolled steel slab. The flywheel was 68 in. in diameter.

The steel industry, vitally concerned with promoting new uses for its products, quite naturally specifies rolled steel wherever practicable for machinery frames, bases and similar construction.



**(Fig. 3)—A 165 ton ladle during the course of construction.**

The fabrication of two 165 ton ladles in a noteworthy instance of equipment made up entirely of rolled steel, fabricated by flame cutting and welding. Over 1,000 ft. of shape cutting was involved in material ranging from 1⅛ to 3 in. in thickness. These ladles were made in two parts, the ladle and the lifting trunnion, each of which are lighter yet stronger than when produced by former methods. Production costs were considerably less. The ladle proper, made up of steel plate 1⅛ to 1⅝ in. in thickness, was over 12 ft. high.

Traveling cranes are another example of special equipment required in steel mills that lends itself to ready fabrication from rolled steel. One crane manufacturer is particularly enthusiastic about the use of flame cutting in his production set-up because most of the cranes built are of special design. Machine flame cutting lends itself readily and economically to this type of production because there is nothing to prepare beforehand. The necessary materials are taken from stock as needed, immediately cut to size and then welded into structure.

The construction of a certain crane involved the use of special tee sections in a size not available from stock. The necessary shapes were readily cut from I-beams by use of a portable, self-propelling cutting machine. Tee shapes prepared in this manner are finding wide use in many types of structures and represent another of the many contributions flame cutting is making to the wider and more effective use of rolled steel.

# THE DIESEL LOCOMOTIVE

## ITS USE IN THE STEEL PLANT

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**Paper presented before the A. I. & S. E. E. Pittsburgh District Section Meeting, November 8, 1935**

▲ AS IS THE CASE with most of our modern industrial activities, the manufacture of steel involves a great many more activities than the actual steel making itself. Ore, coal, limestone, dolomite, and other minerals must be mined and transported to the steel plant, firebrick must be manufactured for lining furnaces, special clays gathered for lining pots, coal must be coked, gas for the furnaces must be available, special machinery must be purchased, electrical energy purchased or generated, and in fact, nearly every branch of heavy industry must be mobilized before a ton of steel may be turned out. Mining engineers, electrical engineers, mechanical engineers, chemists, metallurgists, railroaders, mariners, and a host of other artizans utilize their best talents in order that steel may be made and sold at minimum expense. In each of the attendant industries every effort is made to reduce expenses by the use of modern cost reducing machinery or processes and that industry which finds itself using older and more costly methods of production soon finds itself without any business or profit. It is also natural that the steel plants themselves must employ modern machinery and methods if the price of their steel is to be kept within range of competitive offering.

In boom periods, when the steel-making capacity of the country is taxed to its limit it matters not so much whether equipment is the most modern—there is enough demand so that everyone gets some business. In lean times (such as the past five years) it is easy to claim that there is no real business anyway and plants would not pay even with modern equipment. But, in a post-depression period such as we have now entered, competition is keen and production costs are of vital importance if a steel plant is to get a share of the going business and make a profit. Let us reiterate that the necessity of keeping steel mill equipment on a modern and efficient basis has never been of more importance than at the present time.

American industry is like an airplane—it requires continual driving in a forward direction if it is to be kept afloat, and woe be to that concern that shuts off power and tries to drift on its momentum. New and more economical methods must be thought out and adopted continually, new devices must be employed to save those few cents which were formerly heedlessly spent. Some day this progress may cease, but it will only be when American ingenuity has exhausted its vast store of ideas or when individual initiative becomes unprofitable.

Steel, as a basic industry of modern civilization, is extremely progressive. New products or new methods of producing old products to reduce their cost to the consumer are being developed rapidly. Larger and more efficient furnaces have been developed, drive systems for mills have progressed from the simple noncondensing steam engine to the uniflow engine and finally to electric drive. Everywhere around the blast furnace, the steel plant, and the mills you may see evidence of progress and initiative with a view toward improving the product and reducing the price. One phase of steel production, however, appears to have been somewhat neglected and that is the handling of materials between operations within the plant.

In analyzing the production of steel from the raw materials to the finished shapes or products, one thing which is impressive is the immense amount of material handling involved in the process. Raw materials as received by rail or boat from distant sources must be classified and stored. From such stores coal must be carried to the coke plant at regular intervals; ore, coke and limestone must be fed to the blast furnaces at very definite rates; hot metal, slag, and flue dust must be removed from the blast furnaces on definite schedules, the slag being moved to the dump, hot metal to the steel plant or the pig machine, and flue dust to the sintering plant. The Bessemer converters or the open-hearth furnaces must be supplied with hot metal, pig iron, scrap, dolomite and similar fodder in an unending stream while ingots and slag must be removed from the pouring side at corresponding rates, the ingot buggies being set aside to cool, after which they are again moved to the stripper and soaking pits.

The handling of ingots, blooms, and bars varies in different mills, depending upon the mill layout, but in general it is found necessary to transport these semi-finished pieces from the roughing mills to the finishing mills, the final movements in the chain, of course, being removed from the finishing mills to the warehouses or for shipment. Coupled with this productive transportation chain, is the handling of miscellaneous materials, such as coal for the boilerhouses, clay, brick, sand, crushed slag, by-products from the coke plant,

**A 530 Horsepower Diesel locomotive—60 to 85 tons.**

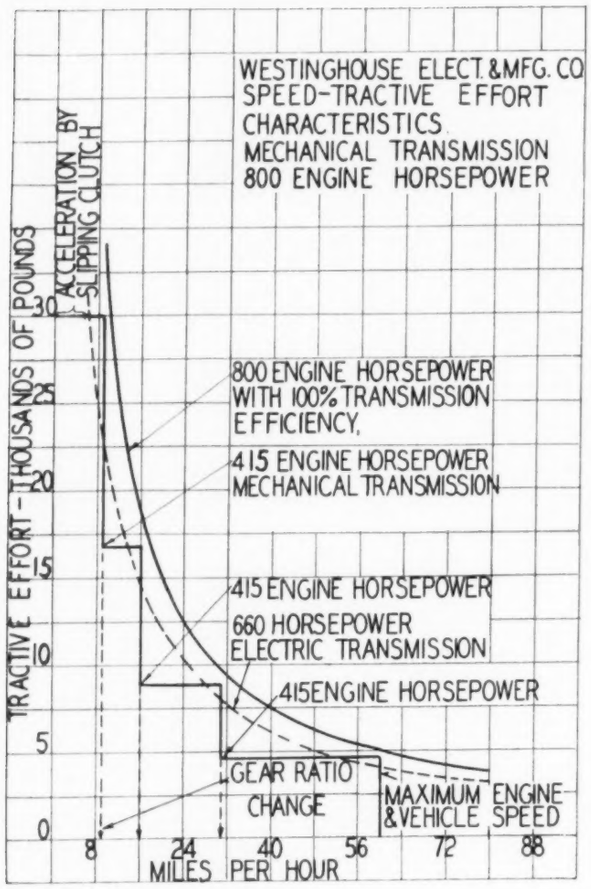
refuse, and similar materials. All in all, the transportation problem around a steel mill assumes considerable importance.

While conveyors, cranes, and transfer tables are frequently used for the handling of ingots, blooms, billets, and bars around a steel mill, the bulk of the transportation problem depends upon rail vehicles. The general nature of the work makes it necessary to employ locomotives for propulsion, although in a few places it is possible to use larry cars for short, scheduled movements. The types of cars used for this material handling vary widely—from standard railroad flats, gondolas, and box cars to slag pots, hot metal ladles, ingot buggies, charging buggies, and special rolling stock found nowhere on rails except in steel mills.

Steam locomotives have been generally used for motive power around steel mills partly because they are flexible in operation and partly because no other type of locomotive has been in existance (until recently), which is as generally suitable for the grueling work. Many attempts have been made to improve transportation costs by the use of other types of power, but their success has been limited because of some feature or other which made them less flexible than steam. As examples of this are: the fireless locomotive, whose radius of operation is limited by its tank capacity and which has the unfortunate habit of quitting work far away from its life-giving steam charging supply; the electric locomotive, whose distribution system usually interferes with other operations; and the storage battery locomotive, whose high battery replacement cost and limited time of operation militate against low operating costs. It is true that each of these types of motive power does have a definite place in some mill operating zones, but for general transportation purposes they are not equal to the steamer. The advent of the locomotive driven by the internal combustion engine, however, definitely changed this picture, as this type of motive power is just as flexible as the steam locomotive and permits of modernizing the mill transportation system in keeping with the progress being made in the equipment of the mills themselves.

Until early in this century the human race had but one commercial method of generating portable power in controllable quantities for propulsion purposes. This was by steam. The commercial development of the internal combustion engine has given mankind its second method of generating such power, and the rapid adoption of such engines for private and commercial road and air travel speaks for itself as to the utility of this second system of power generation. It may easily be seen, then, that with this new method of power generation applied for rail propulsion purposes, the steam locomotive has encountered a powerful competitor. Moreover, actual installations of gas and diesel locomotives in steel mill service have shown that steam locomotives will be unable to maintain their undisputed supremacy in this field.

Just what is this internal combustion engined locomotive? The answer is simple. It consists of a locomotive frame mounted on wheels—either rigid type or truck type—having 2, 3, or 4 or even more driving




**(Fig. 1)—Speed-tractive effort characteristics of an 800 H.P. Diesel locomotive. Electrical and mechanical drives.**

axles. On this locomotive frame are mounted one or more internal combustion engines with their cooling systems together with an operator's cab and auxiliary details. Transmission of power from the engines to the driving wheels may be either by electrical or mechanical means, depending upon which type of drive may be found most suitable.

The decision as to whether a gasoline or a diesel engine should be used as the prime mover is largely one of economies, although the fire hazard associated with the use of gasoline around a steel plant must be given careful consideration. The savings of the diesel engine over the gasoline engine are in fuel and repair expense, and offset against this is the somewhat higher first cost of the former. As long as the engine power is small, commercial gasoline engines may be purchased at slightly lower costs than the diesel. In the larger powered units this is not true, and the gasoline engine has little merit. Thus, when the locomotive power is low so that fuel and repair expenses are minor items, the gasoline engined locomotive has a field. In steel mill work, however, most of the operations involve 24 hours per day service and here the diesel has an undisputed advantage. Normally, diesel fuel for a given cycle of duty costs about one-quarter of the gasoline cost for the same work. Repair expense reduction is due primarily to the absence of spark plugs, ignition wiring, reduced carbonization, lower valve temperatures, and similar characteristics of the diesel unit.

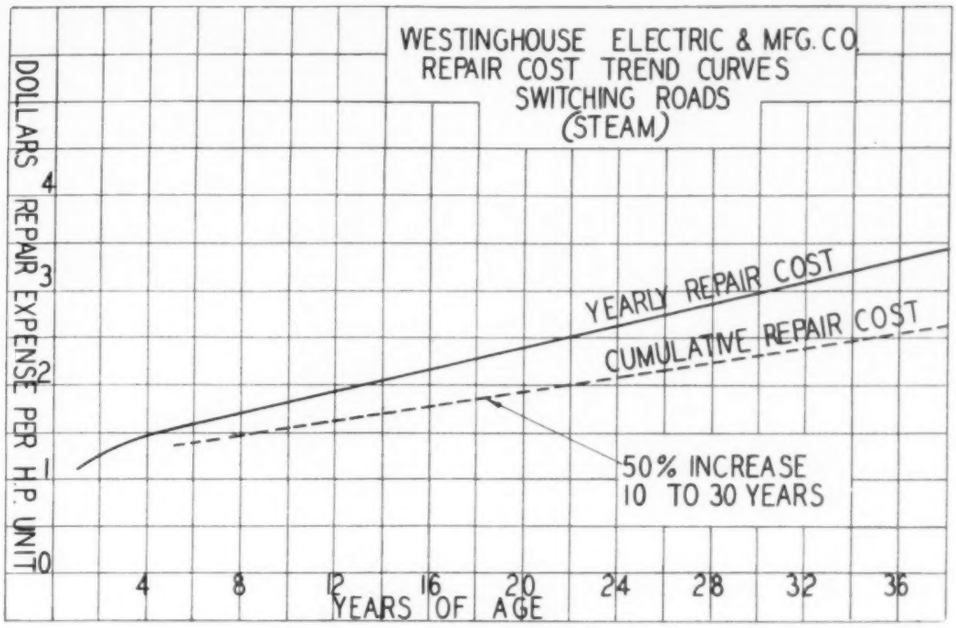
For the general information of those not familiar with the diesel engine, a brief description of this type of prime mover may be of interest. In most respects, the diesel engine is a close counterpart of the gasoline engine, the crankcase, sump, crankshaft, bearings, connecting rods, pistons, rings, cylinders, cylinder heads, valves, cam shaft and such parts being very similar. The fundamental departure from a gasoline engine is in the method of introducing and firing the fuel. The chart following shows the comparative sequence of events within each cylinder of a four stroke cycle engine. The power stroke and exhaust stroke are similar in the two types of engines, but the suction and compression characteristics differ materially:—

| | Gasoline Engine | Both | Diesel Engine |
|---|---|---|---|
| Power Stroke..... (Piston moving downward) | | Fuel fired; power generated | |
| Exhaust Stroke..... (Piston moving upward) | | Piston expels burned gases | |
| Suction Stroke..... (Piston moving downward) | Combustible mixture of air & gasoline vapor drawn in | | Pure air inducted |
| Compression Stroke (Piston moving upward) | *Combustible gas compressed to 100 lbs. and 450° F. | | *Air compressed to 425 lbs. and 1000°F. |
| Firing..... | Compressed gas fired by spark. | | Atomized fuel sprayed into heated air & fires spontaneously. |

*Approximate Values.

The higher compression pressures and temperatures of the diesel engine are responsible for its higher thermal efficiency.

The type of drive used to transmit power from the engine to the locomotive driving wheels really boils down to two general types—mechanical transmission for the very small sizes, with clutches and gear shifting equipment, and electrical transmission for the larger sizes. Pneumatic and hydraulic drives have not proven satisfactory for locomotive purposes. The reason that the electrical form of transmission has prevailed for practically all commercial locomotives of any size is because of the low maintenance expense and greater utility of the engine power. Figure I shows the relative performance of a locomotive with 800 horsepower installed engine capacity when provided with mechanical transmission and when provided with an electrical system. While it is true that the mechanical drive is slightly more efficient, this higher efficiency may be capitalized at very few points only, as over most of the range of locomotive operating speeds the engine




(Fig. 2)—**Typical repair expense trend curve for steam switching locomotives.**

may not be operated to its full speed and capacity. In addition, each time the ratio of gearing is changed, power must be removed from the driving wheels for an appreciable period of time, which makes it difficult to start and accelerate a train. On the other hand, the electrical system adjusts itself automatically and smoothly to changing conditions of load, profile, and acceleration to give the smoothest handling.

Experience has shown that for the normal switching around a steel mill, the most economical type of locomotive is the diesel electric unit. Many surveys of mill switching operations as well as many actual installations have proven this to be a fact. As a matter of interest, a typical example of such a survey is given to show the method of determining the size and number of diesel locomotives required to replace steam motive power, and the economies which result thereby.

The mill which was studied was situated in a very narrow strip of land along a water front, the length of the plant approximating 1½ miles with an average width of approximately 1000 feet. The layout of the plant buildings from north to south is as follows:

Finishing mills and warehouse
Enginehouse
Blast furnaces (4)
Bar mills
Bessemer converters (3)
Mixers (2)
Openhearth furnaces (3)

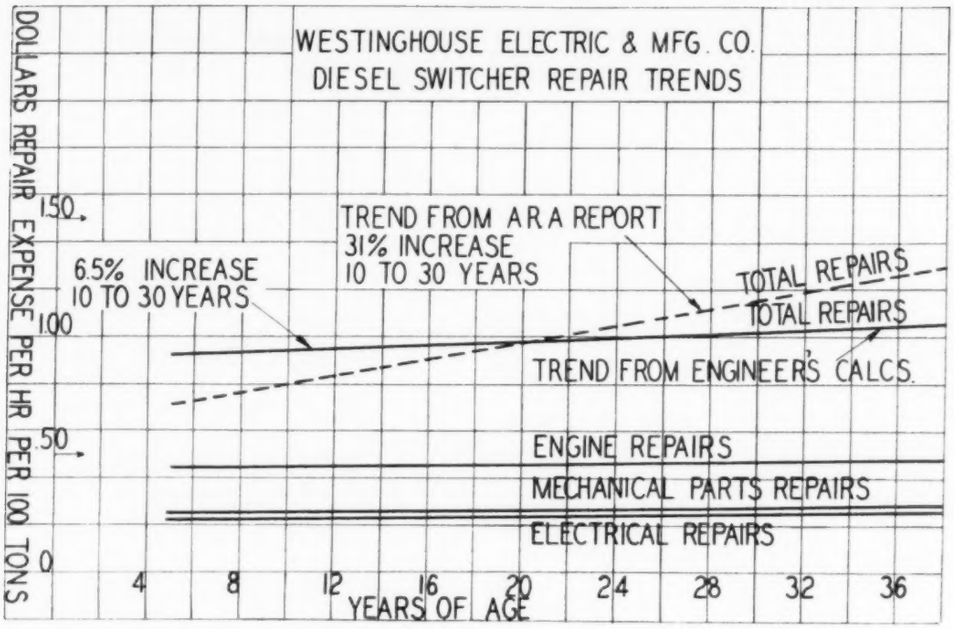
Serving these mills and furnaces are 25 miles of standard gauge track, for the purpose of transporting coke, limestone, and ore to the blast furnace trestle, hot metal from the blast furnace to the mixers, bars from the bar mill to the finishing mills, slag, inbound supplies and outbound finished steel. Some of the ingots from the openhearth furnaces and converters are handled by small narrow gauge dinkies to the bar mills, these dinkies not being included in this survey.

The present assignment of steam locomotives is as follows:

| No. of Locomotives | Hours per Day | Assignment |
|---|---|---|
| 1 | 24 | Hot metal, slag, flue dust. |
| 1 | 24 | Hot steel, openhearth charging floor, and miscellaneous steel works switching. |
| 1 | 24 | Bars to finishing mills, supplies to blast furnace trestle. |
| 1 | 24 | Shipping and general yard work. |
| 1 | 16 | Handling incoming ore to car dumper. (Summer only.) |
| 1 | 8 to 24 | Roust-about work. |

To handle this work, three steam locomotives are available in addition to those for active duty, making a total of nine steam units on the property.

Two severe grades exist within the plant. The ramp from the yard level to the openhearth charging floor and mixers is a 2.4% grade 1600 feet long with a slight curve. The maximum train up this grade consists of two hot metal ladles, the train weight approximating 375 tons. The other grade is to the blast furnace trestle, which is short and has a maximum gradient of 2.65% with an average radius of curvature of 600 feet. The maximum train weight up this grade is 875 tons for 12 hopper cars. In addition to these grades, the curves are numerous, with a minimum radius of




(Fig. 3)—**Repair expense trend curves for Diesel electric locomotives.**

120 feet, while a great many of them are from 130 to 150 foot radius.

The severe grade conditions may be handled by 85 ton diesel locomotives equipped with 530 horsepower in diesel engines. A swivel truck locomotive with short rigid wheel-base is the most desirable type of locomotive because of the sharp curves. By the use of double power plant locomotives so arranged that light switching work may be handled with one engine shut down, it is possible to reduce the number of spare diesel locomotives to one, making a total of seven diesels to replace the nine steamers. Overhaul work on the diesels may be handled during the winter months when ore is not being received, as this ore handling unit is then available as a spare to replace the locomotive going through its overhaul. The idle trick of the ore handling unit in the summer time permits of ample time for rotating locomotives for normal inspection and running repairs.

A careful examination of the operating cost records for the steam, and the known cost records on similar diesel locomotives gives the following expenses for the two types of motive power. It will be noted that this cost comparison includes an item for reduced track maintenance expense, which figure was given by the operating officials and is not a fictitious amount inserted by the diesel enthusiasts for the purpose of improving economies. An examination of the track conditions and known data from other diesel operations indicates that this item of saving may easily be realized.

In this economic comparison the diesel engineer's wage per hour is taken at the same rate as for steam. The fireman, however, is neither necessary or desirable for diesel operation, and has, therefore, been eliminated from the diesel expense.

The total coal burned in 1928 and 1929 was 22,872 tons for a total of 87,288 locomotive operating hours.

## ECONOMIC COMPARISON

### Steam and Diesel Locomotive Operation

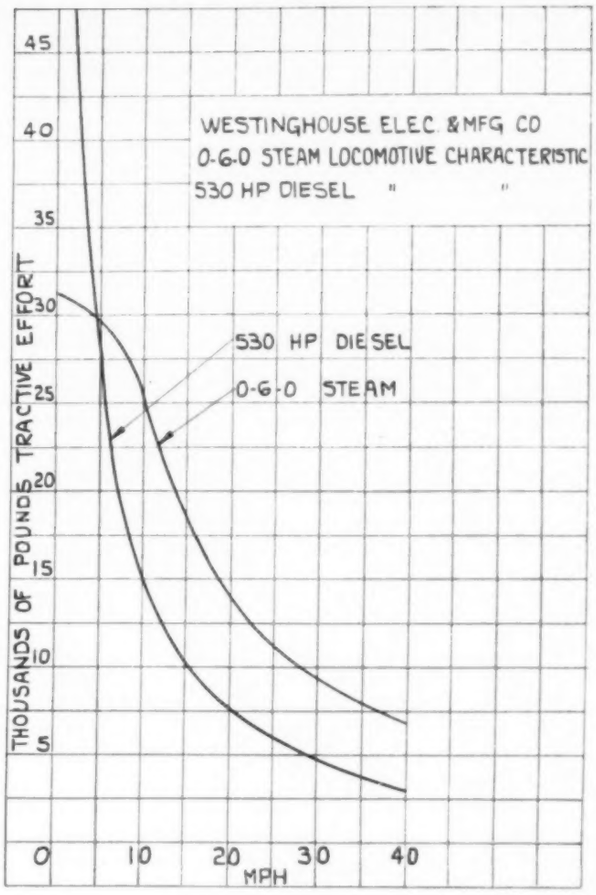
| | Dollars per Hour | |
|---|---|---|
| | Steam | Diesel |
| Wages—Engineer | $0.940 | $0.940 |
| Wages—Fireman | .730 | 0 |
| Fuel | .656 | .178 |
| Repair Expense | 1.690 | .730 |
| Miscellaneous Expense | .560 | .120 |
| Total Operating Cost | $4.576 | $1.968 |
| Fixed Charges | .490 | .975 |
| Total Expense per Hour | $5.066 | $2.943 |
| Locomotive Hours per Year | 43000 | 43000 |
| | Steam | Diesel |
| Total Yearly Expense | 217,838.00 | 126,549.00 |
| Savings per Year by Diesels | | 91,289.00 |
| Saving in Track Maintenance | | 11,500.00 |
| Total Saving | | 102,789.00 |
| In Relation to Diesel Investment | | 22.6%* |

*Approximate

This figures 525 lbs. of coal per locomotive hour which conforms to operating averages for this size of 0-6-0 steam unit. Coal costs $2.60 per ton on the tender, so 525 pounds costs $0.682. Assuming that the average coal cost over the next ten or fifteen years will be $2.50 per ton instead of $2.60, we get an hourly fuel cost of $0.656. Now in comparing the diesel fuel cost with the steam fuel cost, reference is made to statistics published by the American Railway Association (now the Association of American Railroads) in 1932, wherein it is shown that the ratio of pounds of steam locomotive coal to gallons of diesel locomotive fuel for equivalent service is 140 to 1, we can translate the 525 pounds of locomotive coal per hour into 3.75 gallons of diesel fuel per hour and at the prevailing price in this locality ($0.0475 per gallon) gives an hourly diesel fuel cost of $0.178. This agrees closely with known costs in steel mill and other industrial applications.

In making a comparison of steam and diesel locomotive repair expense in a case of this kind it is not fair to take either the present repair expense of the steam locomotive or the maintenance of the diesel for the first few years, because neither is representative of the true cost over the life of the locomotive. Locomotive overhaul costs may not appear in the current items of expense yet such overhauls are an inevitable part of the total maintenance expense both for steam and for the diesel. In order to insure that the total repair costs are included it is necessary to consider such expense items over a long period of years, taking the average cost for each type of motive power to use in the economic comparison. In this particular case, a careful study was made of the past steam locomotive repair costs over a long period of years to determine the future trend of costs. It has been demonstrated that for any locomotive the repair expense gradually rises with increase in locomotive age, the rate of rise differing for different types of locomotives and for different properties. A typical steam locomotive repair trend curve is shown by Figure II, the solid line being the year by year repair costs and the dotted line being the average expense to any given age of locomotive. It may be noted that these costs are plotted in cost per "horsepower unit", a "horsepower unit" being a function of the boiler capacity and miles per hour of the locomotive. While the present repair expense for the steam locomotives at this particular mill is not quite as high as $1.69 per used in this comparison, the indicated rate of increase per year is such that the average over the next 15 years of operation will more than equal this figure.

Since diesel locomotives are relatively young, some prognostication must be made of expected repair expense and rate of rise of this expense as the locomotive grows older. Again reference is made to the statistics published by the American Railway Association, from which a repair expense trend curve has been derived. In addition, an operating executive of a small railroad formerly using steam locomotives and now using diesel motive power has made an exhaustive study of diesel repair expense from his past steam experience and his present diesel operation. From this has been derived a repair expense trend curve. Figure III shows this derived curve, with the A.R.A. curve shown by a




(Fig. 4)—**Characteristic curves 0-6-0 steam locomotive. 530 H.P. Diesel locomotive.**

dotted line. Thus, for an 85 ton diesel locomotive we find that the average repair expense over a 15 year period is $0.73 per hour. Actually, as operators become more familiar with diesel equipment, this repair expense will undoubtedly be reduced (if experience with electric locomotives may be indicative of trends) although no credit is taken for this expected reduction.

The item of miscellaneous expense for the steam locomotives covers water, enginehouse expense, lubrication and supplies. With the method of accounting used these various expenses could not readily be segregated. For the diesel locomotive, lubrication averages approximately one-third of the fuel expense, so this item was taken at $.06 per hour. Supplies are normally in the neighborhood of $.02 per hour while water cost is negligible. Enginehouse expense is very materially reduced as compared to steam because there are no fires to clean, ashes to dispose of, fueling is less frequent and off hours attendance is eliminated. Based upon figures determined in other steel mill operations, this expense was taken at $.04, making a total of $.12 in comparison with the $.56 for steam.

The fixed charges for steam and for diesels include interest on the motive power investment and depreciation at the rate of 4%. The higher fixed charges for the diesels reflect the higher purchase price of this type of motive power as compared to steam.

It may be noted that the same number of locomotive hours per year are used for both steam and diesel motive power. Actually, the diesel switches faster than steam and can handle a given service in shorter time. Where advantage may be taken of this feature to reduce locomotive and ground crew hours, additional savings will be made above those shown. In a great many steel mill operations, however, the locomotives must be on duty ready for service at a moment's notice and the crew hours remain fixed even though the locomotive is not being actively used.

In making the selection of a diesel locomotive to replace a known size of steam unit or to handle a given service, the maximum conditions are usually the most important considerations. Weight of locomotive on drivers is determined by the loads to be handled up the most severe grades and engine horsepower is determined by the speed necessary in timed movements. Figure IV shows the characteristics of a steam locomotive of the 0-6-0 wheel arrangement and of a 530 HP diesel, while Figure V shows the relative performance of this 0-6-0 steamer and a 530 horsepower diesel. Comparisons similar to Figure V show that the diesel is faster on switching movements as follows:—

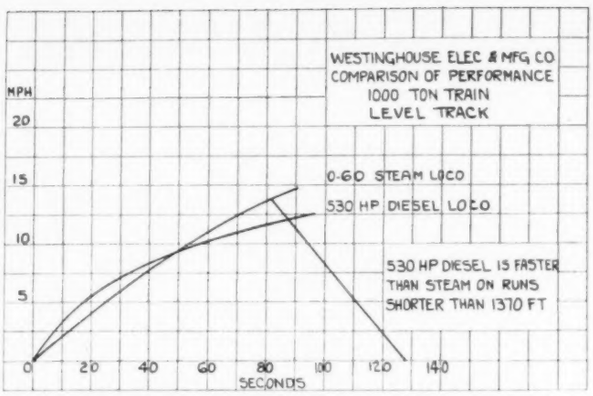
| Weight of Trailing Load | Diesel Is Faster On Moves Less Than |
|---|---|
| 500 | 1000 feet |
| 1000 | 1370 " |
| 1500 | 1965 " |
| 2000 | 2910 " |

While some time may be lost occasionally on the few runs longer than those given above, the majority of moves are considerably shorter, and the time saving on these frequent short moves far more than compensates for the longer runs.

It may be noted from Figure IV that the steam locomotive has potentially much more horsepower than the diesel unit, yet from Figure V the diesel out-performs the steam. This is largely a function of the ability of the diesel to get away faster with a train, the steam locomotive requiring considerably more time to cover the initial distances than the diesel.

With the weight and horsepower of the diesel locomotive determined, the physical dimensions must be given consideration. It is almost invariably found that steel plants are laid out with little consideration of the railroad requirements and, in order to serve the various buildings, sharp curves, close clearances and steep grades are the rule. It has been found that the swivel truck type of locomotive with its short rigid wheel base negotiates practically any curve with fewer derailments than the steamers with their longer wheel bases, resulting in fewer delays from this cause.

The heart of the diesel locomotive is the engine. The mechanical parts of the locomotive and the electrical transmission system are known and proven items requiring but reasonable care in their selection. The success or failure of a diesel installation from an operating or economic standpoint, however, depends upon selecting an engine which has long operating life and reserve power to insure the required performance, between overhaul periods. This point is emphasized




**(Fig. 5)—Relative performance 0-6-0 steam locomotive. 530 H.P. Diesel locomotive. 1000 ton train.**

because of the fact that some engine builders in the past have made it a practice to rate and install their engines on the basis of their optimum block test ratings and when such locomotives were placed in service they were found to be not only inadequate but expensive to maintain. An engine for locomotive purposes should be capable of delivering continuously when new at least 10% more power than its rating when installed on a locomotive and operating with the cooling system of the locomotive. Such reserve capacity insures that even with the general deterioration in engine condition which must be expected between overhauls, the reserve capacity may be called upon to keep the engines up to their rating and the locomotive to its expected performance.

Summing up the diesel locomotive advantages as applied to steel mill material handling, it may be pointed out that the ultimate objective in the use or substitution of this type of motive power is to reduce the cost of steel production. Records of actual installations show that the diesel is the most economical locomotive as yet developed for industrial and steel mill applications where the hours of operation per day warrant the somewhat greater investment in this type of motive power. These savings are effected by reduction in crew expense, fuel cost, repair cost and enginehouse expense. In addition to measurable cost reductions, there are other cost reductions and advantages of a somewhat intangible nature, which often result from the use of these locomotives, among these being:

- Smooth and even starting torque reduces the danger of slopping hot metal from slag pots and ladle cars.
- Derailments of motive power are infrequent due to short rigid wheel bases.
- Absence of smoke and steam improves visibility and reduces hazards of operation.
- Higher tractive efforts make it unnecessary to take a long run for grades.
- Reduced enginehouse requirements often permits of releasing valuable ground for mill expansions.

Present-day competition demands that steel production costs be reduced to a minimum for every step of the process from the mining of the ore and coal to the final rolling. The diesel electric locomotive fulfills this requirement for plant transportation motive power.

# DISCUSSION

PRESENTED BY

H. B. AYRES, H. K. Porter Company, Pittsburgh, Pa.

W. C. VAN BLARCOM, Superintendent, Aliquippa & Southern R. R., Aliquippa, Pa.

J. W. HOOVER, Transportation Division, United States Steel Corporation, Pittsburgh, Pa.

F. E. WYNNE, Railway Engineering Section, Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

R. M. MULLEN, Duquesne Light Company, Pittsburgh, Pa.

S. B. SCHENCK, Special Engineer, Bessemer and Lake Erie Railroad Company, Greenville, Pa.

K. B. DICKSON, Carnegie-Illinois Steel Corporation, Edgewood, Pa.

H. P. BENDER, Mechanical Engineer, Pittsburgh and Lake Erie Railroad, McKees Rocks, Pa.

J. R. SLOAN, Electrical Engineer, Pennsylvania Railroad, Pittsburgh, Pa.

WALTER GREENWOOD, Youngstown, Ohio

D. M. PETTY, Superintendent of Service Division, Bethlehem Steel Company, Bethlehem, Pa.

A. H. CANDEE, Diesel Electric Engineer, Westinghouse Electric & Manufacturing Company, Philadelphia, Pa.

G. E. STOLTZ, Mining and Metal Working Electrical Section, Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa.

B. H. KERSTING, The Dravo Contracting Company, Pittsburgh, Pa.

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*H. B. Ayres:* I had the privilege of designing some of the detail parts for what I believe was the first railroad electric locomotives, in the early 90's. They went down to the tunnel in Baltimore. I was with the old Schenectady Locomotive Works at the time. After the locomotives were built I was sent down along the burm bank at Schenectady to witness the test. While there a job was offered me and the argument for accepting it was about as follows: "You better come down with us; five years from now there won't be any more steam locomotives." But we are still building them, or at any rate we are still trying to sell them—no one is building very many of any sort at present. I am glad Mr. Candee did not make any such prognostication regarding the Diesel locomotive.

We build Diesel locomotives and have nothing but good to say about them; however, they are not a cure-all for all jobs by any means. They have their place and in the right place I think are preeminent. I cannot agree that the figures put on the screen tonight by Mr. Candee show up universal conditions. I have seen figures put up by operators of both types in some other cases which do not look much like his. I have no quarrel with the figures given—they might be perfectly all right for some cases, but they absolutely are not all right for all cases. I am going to venture this, gentlemen, that anybody who buys a locomotive today, if he serves his own purpose best, will look into the work which has to be done pretty carefully. He will find that neither the steam locomotive, nor the Diesel, nor the electric, nor any other one type is a cure-all or the answer for all the questions which will be brought up. So I say, carefully consider your jobs and pick out the locomotive which is best for it, whether a steamer, Diesel, electric, storage battery, or whatever because they all have their place.

*W. C. Van Blarcom:* I have appreciated the very interesting and clear talk to which we have listened. I do not think there is any doubt but what the Diesel locomotive has its place. Indeed it is coming into rather common use. I have not had any experience with it, so cannot give you anything on the Diesel. But I might offer a word on the steam locomotive.

Most of the operating cost comparisons made between steam and other motive power, appear to compare the Diesel or other motive power with the steam engine of rather ancient vintage. This is rather natural, as most of the present switchers are far from modern and are unduly costly to operate. It is rather difficult to get costs on real modern switching power. There is no doubt but that the old saturated steam engine is fast becoming obsolete, and should be replaced as motive power in steel mills and on railroads: it needs to be modernized. But, as Mr. Ayres mentioned, each individual case requires special study as to the form of modernization.

I might offer an illustration: Five years ago we purchased a couple of modern steam locomotives. They replaced three old ones over 20 years old at that time. The two new ones were more powerful units; in fact, each had about 50% more power than the smaller saturated engine replaced; and yet, with 50% more power it had a lower fuel consumption. That gives an indication of what a modern steam engine can do as compared with an old one. We have also had experience with superheating engines formerly using saturated steam, and find a 40% saving in fuel.

Another item enters into this subject, and that is the quality of boiler feed water. I suspect many of the quoted locomotive repair costs are based on steam locomotives where the boiler feed water is not all that might be desired; and as steam locomotive people know, that greatly increases the repair cost and also the consumption of fuel and water. Around steel mills with their modern boiler plants, there are usually treating plants for boiler feed water, so that it should be possible to get better water there than on many railroads. This should reduce the cost of their locomotive repairs as compared with those quoted from the American Association of Railroads.

My point is, that when obsolete steam power is to be replaced, consideration may well be given to the

savings to be secured by the use of modern steam power. Then the particular circumstances in each case will indicate what form of replacement will yield the most attractive return on the investment required. Different forms of motive power have advantages and disadvantages, varying in net effect according to the combination of conditions met in each situation studied.

The replacement of obsolete power offers an attractive opportunity for lowering transportation costs. The paper tonight is a helpful contribution to this subject.

*J. W. Hoover:* I listened to Mr. Candee's paper with a great deal of interest and his story has not changed very much in the past three years. Some three years ago our people thought that our yard switching costs were getting away from us, so we made an investigation of these costs at our plants. The result of that study convinced me beyond question that in switching at steel plants there is a place for three types of power at least, viz.; steam, Diesel and the fireless locomotive. As Mr. Ayres has said, each job requires a thorough study in order to determine which of these types of power is the more economic and efficient. I have in mind a certain switching operation at a plant in Ohio where a steam locomotive with a five-man crew made only about six moves a day at a blast furnace trestle. The rest of the time the locomotive and crew would be idle, or had to make long trips to another part of the plant which was uneconomic. A fireless locomotive was purchased to do the work. Only two men are now required in the operation and about 75 percent of their time is taken up by other duties at the plant furnace. The fuel cost is negligible. I think, Mr. Candee, in a place like that, the fireless locomotive is the answer.

In our study of Diesel electric locomotives two important adverse factors were encountered. One of these was the high first cost but with increased production of these locomotives the cost is falling. The second factor was the maintenance, or repair cost. This cost is difficult to evaluate. As I see it there can be no real comparison between the Diesel electric and steam for some years to come. There are men here who have had more experience than I on locomotive costs, but I do know that, at least some of our plants, the cost of repairs to steam locomotives is not as great as the figures set up by Mr. Candee. Mention is made of the acceleration of the Diesel electric locomotive over steam. There is no question that at speeds below eight miles per hour the Diesel has faster acceleration than steam but in our investigation we found a come-back on that feature. Crews complained that due to this faster acceleration they were completely worn out at the end of their tour of duties. They also claimed that the Diesel had to wait for them rather than they having to wait for the steam locomotive. I have not yet made up my mind if this is a good argument for or against the Diesel. Another adverse factor which we encountered was that in some states the law is mandatory in requiring two men on an engine in switching service, which of course cuts down anticipated savings. Regardless of all this, Mr. Candee, I am still Diesel minded and believe that its field of use will widen out as first costs come down.

*F. E. Wynne:* I would like to agree with Mr. Ayres statement that there is no one form of locomotive that is a cure-all for transportation. The steam locomotive has its place. The same thing is true of the Diesel locomotive and of the fireless locomotive. In any particular study it is necessary to take into account all of the factors, particularly the economic factors, as indicated by Mr. Candee's tabulation. As to the point of getting superior performance with modern steam locomotives, a comparison taking into account that superior performance should include also the amount of money you have to spend to get those new steam locomotives. The more jewelry you hang on a locomotive, the greater becomes the repair cost. That is pretty well established, I think.

At times, there has been a bugaboo raised regarding what the probable Diesel savings may be in the future; that being based on the assumption that in the future fuel oil will cost a great deal more than now. In looking at the figures Mr. Candee had on the screen, I note that the cost of fuel oil is but a small portion of the total cost of operating the Diesel. Suppose that cost were doubled. Then the savings, as a percentage on the investment for Diesels, would be reduced only to 20.5% instead of 22.6%. In other words, a locomotive would still pay for itself in five years instead of four and one-half years, and anything that will pay for itself in five years is a pretty good investment.

Where a Diesel application is made you do not have to wait for results; you begin to realize savings the very day it is put into operation and these continue and accumulate from then on.

*R. M. Mullen:* I do not think I can add very much to what Mr. Candee said, except that when you employ two or three locomotives, the trolley type should be considered. I think the application of a Diesel locomotive in short switching service replacing several steam locomotives should be given careful study, and it is more than likely possible to reduce cost. However, where you have more than one locomotive, the lower first cost of the trolley type locomotive offsets the cost of substations and overhead systems. The cost of the trolley system divided over two or three locomotives will show cheaper first cost than the present Diesel type. Maintenance of the trolley type is lower and under present conditions, the energy cost will not be any greater.

Of course, I cannot discuss the advisability of the use of a trolley system in the mills.

*S. B. Schenck:* The Bessemer & Lake Erie Railroad Company have no Diesels yet so we have had no practical experience with them. I might add that in some studies made lately by the Federal Co-ordinator, figures on Diesel locomotive first costs were given and it was interesting to note that the average cost of $200 per engine H.P. in 1925 had come down to about $125 per H.P. at present. That is a move in the right direction.

*K. B. Dickson:* I have not very much to add to what Mr. Hoover has said. My experience has been about the same thing, and I would like to second the

remarks made by Mr. Van Blarcom about maintenance of steam engines, where he mentioned the feed water as being one of the causes of expense. Sometime ago we made a study or comparison of costs in the different mills, and we found quite a variation, and could only attribute this variation to feed water, plant facilities for repairs, efficient supervision and effective use of engines, which goes back to the fact that around an industrial plant, the transportation facilities are looked at as a necessary evil, and they are sometimes thought to be not very necessary at that.

The costs we have been able to develop varied both ways from the costs Mr. Candee shows this evening. We have at some plants, as Mr. Candee knows, costs that were much lower and some plants where the costs were higher. I would say that Mr. Candee's costs as shown on his charts were a fairly good average judging from our studies.

*H. P. Bender:* I came to listen not to make any remarks, but I want to say that I enjoyed the talk of Mr. Candee very much, as well as the other pertinent remarks made since the talk. Nearly all comparisons I have seen have been comparisons made I presume with Diesel locomotives in a field where they have their real application. (Switching service.)

I hope the time will soon come when the application may be extended to a much broader field than at present, that is of course, where it proves to be economical to use the Diesel.

One point that Mr. Candee might have stated in favor of the Diesel locomotive is its flexibility, that is the ability of a Diesel locomotive with the swivel type of truck to negotiate very much sharper curves than can be negotiated by the steam locomotive with its longer rigid wheel base. This is an important point when switching around industrial plants.

*J. R. Sloan:* I do not think I can add anything about Diesel locomotives. We have none in our region and I have had no personal experience with them, but I have had practical experience with a gasoline locomotive which was furnished for test by the H. K. Porter Co., (Mr. Ayres). A trial was made against steam locomotive. The steam locomotive did the work in an 8-hour trick, whereas the gasoline finished the work about 2:00 P.M. or an hour less time. While working with the steam locomotive the engineer was keeping the ground crew back, by not acting promptly when the signal was given to reverse. When we had the gasoline locomotive operating, the reverse signal was acted on promptly and with the more rapid acceleration the ground crew were kept on the run.

*D. M. Petty:* The ability of a Diesel locomotive to accelerate quickly go fast around curves and otherwise handle easier, enables it to do more work per locomotive hour. This is one of the principal savings in many cases.

*Walter Greenwood:* There is one feature in the construction of all locomotives that is not as generally appreciated as I feel it should be, namely, placing passenger style platforms on both ends. Along with best method for generating power consideration necessarily must be given to efficiency in operating; this includes safety, maintenance cost and highest practicable speed in movements. My observation proves that the most frequent of fatal railroad accidents occur where locomotives are equipped with foot-boards for employees to ride on when engaged in switching service. Regardless of rules laid down which forbid employees to get on foot-boards while the locomotive is moving, they will do it and anyone familiar with switching service knows such rules cannot be enforced.

It has been shown that the cost of installing foot-boards and maintenance for a period of two years, the average cost, taken from a group of locomotives, will exceed the cost of installing passenger style platforms on a similar sized group and maintenance cost will be practically nothing. Of course the cost of changing from foot-boards to passenger platforms on used locomotives exceeds the cost of installing on new locomotives, and because of the cost entailed in making such changes railroad managers are loth to give the entire subject proper attention. So far there is no record of a serious accident, such as occur from getting on foot-boards, where locomotives are equipped with passenger type platforms.

*A. H. Candee:* First answering Mr. Ayers in regard to steam locomotive, each type of locomotive has its place. We do not say that the Diesel is a cure-all; on the other hand we do say that the steam locomotive has a serious competitor in the Diesel locomotive.

Mr. Van Blarcom remarked about comparisons he has seen that were made on the basis of saturated steam locomotive. We have made comparison with both types of steam locomotives; not only that, but we have compared new steam locomotive with new Diesel motive power. Referring to those curves shown this evening, the costs were taken on a 15-year life for both steam and Diesel, which is starting both from scratch. It is true that saturated steam locomotives do differ in fuel and water consumption from the superheated types. We have compared the Diesel with both types and there are advantages to be shown as against either type. As it happens, we have also made some comparisons in steel mill service where savings would not justify the Diesel locomotive. It has been remarked that each application should be considered carefully to make sure the type adopted is a paying proposition. We agree with that.

Mr. Hoover mentioned the fireless locomotive. We tried to bring out in the paper that where the locomotive is being used 16 to 24 hours a day, (as is usually the case around steel mills), fuel and repair expense is an important item; there is where the Diesel shows best economies. In the case of the fireless locomotive cited, where it made only a few moves a day, there would be no justification for gasoline or Diesel as compared with the fireless locomotive. As far as locomotives being too fast for ground crews is concerned, that is a general criticism, of ground crews where Diesels replace steam locomotives.

As far as electrification is concerned, we believe there is a place for electrification around steel mills, but it is frequently difficult to put contact systems around a plant, such as around blast furnaces and open hearth charging floors.

Mr. Bender of the P. & L. E. predicts that there will be an extension of the Diesel locomotive to other fields than steel mill and other industrial plants and railroad switching. We agree with that, but it will be some time before that happens. The reason the Diesel is comparative with steam in switching service is that a small horse power Diesel will do what a large horse power steam locomotive will do because the moves are relatively short. Where runs are long, more horse power is needed until the horse power of the Diesel becomes nearly as much as horsepower of steam. That makes the cost ratio become somewhat higher, so that justification for main line Diesels is not here yet. As they are built in increasing quantities and the field broadens, different conditions will obtain.

In regard to operation on curves, I tried to bring that out in the paper that there was a decided advantage with the short wheel base Diesel locomotive over the longer rigid wheel base steam locomotive.

We will admit there are wide variations in costs obtained from different mills. In one case we found a mill using 8-wheel switchers of superheater type using 400 pounds of coal per hour. How they do it, I do not know, as such locomotives should use 600 to 800 pounds of coal per hour. It is one of those things you can't grasp. Sometimes I think the steam figures are fixed to make their costs look small, but you cannot go back of the cost figures given by the operators. What we try to do in making a survey of a steel mill or railroad application above everything else is to be honest; there is no use trying to fool anybody.

*G. E. Stoltz:* As to the future of Diesel-electric locomotives for switching, I wouldn't care to venture an opinion, but I cannot help but feel there is a place for this equipment in yard switching, particularly in view of the experience we have had in the petroleum field where Diesel-electric equipment is used for drilling. Its chief application is in districts where water is scarce, or for what is termed wild catting, or prospecting for new fields. Two Diesel-electric rigs were placed in the Mid-Continent field about six years ago and it has only been during the last year and a half that additional Diesel-electric equipments have been sold in this field. This increased activity has been quite pronounced during this last year and a half and came to us somewhat as a surprise. Once we made a start, there seemed to be a continuous flow of orders going through our factory.

Previous to the last year and a half we had a feeling that there would be no great future for Diesel-electric drilling due to its higher first cost. This is particularly important in the petroleum field as this drilling equipment is purchased by contractors who are not in the same position to finance Diesel equipment as large industrial companies are. This last summer, I had the pleasure of seeing a number of these Diesel-electric rigs in operation and most of them were operated by men who were not particularly well acquainted with the design of Diesel engines. In one instance an electrician seemed to have charge of the Diesel engines as well as the electrical equipment. The men who drill these wells, as a rule do not have a great deal of mechanical training so that all in all these Diesel-electric equipments are making a very good showing in a field where the conditions are not ideal. We feel that when business conditions improve there will be a number of steel companies that should give very careful thought to the purchase of Diesel-electric locomotives for switching. Many of the steam locomotives now in the plants are obsolete and in poor condition so that no doubt new locomotives of one type or another will be purchased, and if there is ever a time when careful consideration should be given to Diesel-electric locomotives, it should be at this time of improved business conditions.

*B. H. Kersting:* The fuel oil consumption figures as shown on the chart appear to be very low and I would like to ask Mr. Candee whether the figures on this chart include the fuel consumption due to idling of the Diesel engine. When it is considered that the Diesel engine uses fuel during idling time and that the steam locomotive generates steam while standing-by which is stored in the boiler, it would seem that the Diesel engine would be at some disadvantage when used for switching service encountering much starting, stopping and waiting.

*A. H. Candee:* That is perfectly true. The basis on which that comparison was made was the average fuel consumption in a particular type of switching service. A steam locomotive uses 525 pounds of coal. We know that corresponding Diesel fuel is about one gallon to 140 pounds of coal. That does not represent full load fuel rate of the engine. In yard switching service power is on about one-quarter the time. A locomotive is moving about one-half the time and standing about one-half. In steel mill type of switching where you may have a locomotive waiting for some particular operation at the blast furnaces or open hearth, the Diesel engine is standing still and consuming no fuel. The steam locomotive is standing still but is consuming fuel to offset radiation losses. In average service, the figure of 3¾ gallons of fuel per hour that we give covers the type of service and not continuous full-load operation.

▲

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# ▲ ▲ ▲ ITEMS OF INTEREST ▲ ▲ ▲

**E. E. Reagle,** formerly superintendent of the Sharon Works of the Sharon Steel Hoop Company, has been named the general superintendent of all plants of the newly named Sharon Steel Corporation.

Mr. Reagle was educated in Grove City College and Case School of Applied Science in mechanical engineering and started in the steel business on the drawing board at the Cambria Steel Company in 1914. While associated with the Cambria Steel Company, Mr. Reagle served as mill foreman at the Gautier works, Johnstown, Pa., superintendent blooming and finishing mills, Wilmington, Del. plant, superintendent blooming and plate mills, Franklin works, Johnstown, Pa.

In 1920 Mr. Reagle went with the Sharon Steel Hoop Company as night superintendent of the open hearth and blooming mill. In 1922 he was appointed assistant superintendent of the Sharon Works and in 1931 general superintendent, which position he held until his recent promotion.

▲

**J. M. May** has been named the assistant general superintendent of all the plants of the Sharon Steel Corporation. Since his graduation from the Sharon High School in 1907, Mr. May has been continuously in the employ of this company. Starting as an office boy at that time he has worked himself through the operating department in the blooming mill and open hearth, chief shipper and chief inspector then to sales in charge of schedules. In 1932 he was appointed production manager of the operating department and March 1, 1936, assistant general superintendent.

▲

**W. S. Jackson,** as announced by the Sharon Steel Corporation, has been appointed the general superintendent of the Sharon plant. Mr. Jackson started with the Sharon Steel Hoop Company in 1902 as marking boy in the shipping department. During the war period he was the bundling foreman and night hot mill superintendent. From 1923 to 1932 he was day hot mill superintendent and from 1932 to 1935 assistant general superintendent of the Sharon plant.

▲

**L. L. Wilson** has been promoted to be the assistant general superintendent of the Sharon plant of the Sharon Steel Corporation. Mr. Wilson was graduated from Pennsylvania State College in 1913 and began work with the Carnegie-Illinois Steel Corporation. In 1920 he left this company to become the safety engineer for the Sharon Steel Hoop Company. Later he was transferred to the engineering department and from there to the operating department. He was successively, assistant superintendent and superintendent of cold roll department, superintendent of finishing departments up until his recent advancement.

▲

**J. A. Carter,** as announced by Henry A. Roemer, president of Sharon Steel Hoop Company and the recently acquired Pittsburgh Steel Company, has been appointed general superintendent of the Monesson mills of Pittsburgh Steel. Mr. Carter was formerly works manager of the Lowellville plant of the Sharon Steel Hoop Company. Mr. Carter is a graduate of Rose Polytechnic Institute.

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**R. C. Butler,** formerly superintendent of the blast furnace department of the Lowellville plant of the Sharon Steel Hoop Company, has been appointed superintendent of the blast furnace department of the Pittsburgh Steel Company, Monesson, Pa. He succeeds George W. Hughes in his new position. Mr. Hughes retains his connections with the Pittsburgh Steel Company.

E. E. REAGLE

J. A. CARTER

J. M. MAY

W. S. JACKSON

L. L. WILSON

R. C. BUTLER

**Francis Hodgkinson,** one of the outstanding figures of the engineering profession recently retired from the employ of the Westinghouse Electric and Manufacturing Company which was marked with a dinner given in his honor by the employees of the Company's South Philadelphia Works, at the Racquet Club in Philadelphia.

Co-worker with Sir Charles Parsons and later right hand man of George Westinghouse in the development of the steam turbine in the United States, Mr. Hodgkinson leaves Westinghouse Company after 42 years of outstanding service to that company and to the Engineering profession.

Francis Hodgkinson was born on June 16, 1867 at London, England. Educated in the Royal Naval School New Cross, England, he was apprenticed in 1882 to Clayton and Shuttleworth Agricultural Engineers, Lincoln, England. In 1885 he became associated with Sir Charles Parsons in the early development of the reaction steam turbine.

In 1890 his services were requested by the Chilean Navy which organization he joined and served during the revolution of that time. From 1892 to 1894 he was engaged in work for the Telephone and Electric Light Company of Lima, Peru, and in connection with mining properties at Casapalca, Peru.

In 1894 he rejoined C. A. Parsons and Company becoming superintendent of the erecting and fitting shops. In 1896 when George Westinghouse negotiated a license agreement with Sir Charles Parsons, Mr. Hodgkinson at the latter's recommendation came to the Westinghouse Machine Company to initiate the designing and construction of steam turbines. He was responsible for steam turbine construction until 1916 when he was made Chief Engineer, responsible for all steam power apparatus of the Westinghouse Electric and Manufacturing Company.

In 1926 he was made Consulting Mechanical Engineer for the Westinghouse Electric and Manufacturing Company, which position he has held until the time of his retirement. During this period he has been the principal U. S. delegate to the International Electro-Technical Commission.

**Professor Robert Ernest Doherty,** dean of the School of Engineering at Yale University, and authority on technical education, was chosen President of the Carnegie Institute of Technology, the Board of Trustees announced Feb. 25, 1936.

The appointment was effective as of March 1, the trustees announced, although Dean Doherty will not come to Pittsburgh permanently until the close of the college year when he will have completed his duties at Yale.

The new appointee will be the third president of the Carnegie Institute of Technology, succeeding Dr. Thomas Stockham Baker, who retired in September, 1935, because of ill health. Dr. Arthur Arton Hamerschlag was Tech's first head.

Dean Doherty, former associate of the electrical wizard, Dr. Charles P. Steinmetz, has been a member of the Yale faculty since 1931 when he was appointed professor of electrical engineering. Three years ago he was advanced to the post of dean of the engineering school, the position he holds at the present time.

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**Charles Fleisch** has been appointed assistant superintendent of the Carrie Furnaces, Carnegie-Illinois Steel Corporation, Rankin, Pa., to succeed Edward T. Warren who was recently appointed superintendent of blast furnaces of the Edgar Thomson Steel Works.

Mr. Fleisch began his business career with the Carnegie Steel Company, Homestead Works, in January, 1919, in the mechanical Engineering department; was promoted to asst. special engineer in 1924; and was transferred to Carrie Furnaces in December, 1928, to date.

He is a graduate of Carnegie Institute of Technology with the degree of mechanical engineering.

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**A. D. Brown** has just been appointed manager of Allis-Chalmers Los Angeles District Office to fiill the vacancy recently caused by the sudden death of Mr. Boyd Anderson. Mr. Brown for many years was manager of the Company's Buffalo District Office.

J. D. WRIGHT

KARL H. RUNKLE

**J. D. Wright** and **Karl H. Runkle** were appointed assistant managers of the General Electric Company's industrial department, effective February 24, according to a recent announcement made by J. E. N. Hume, manager of the department. Prior to their promotions, Mr. Wright was assistant head of the industrial department's engineering staff and Mr. Runkle was manager of sales of the department's mining and steel mill section. Both entered General Electric employ as student engineers on the "test" course shortly after their graduation from college.

Mr. Wright, a native of Wisconsin and a graduate of the University of Wisconsin with a B.S. degree in engineering, joined the company in 1909 and, after completing the test course, was transferred to the industrial-control engineering department. In 1915 he went to the industrial engineering department, becoming head of its steel mill section in 1922 and assistant head of the department in 1930.

Mr. Runkle, a native of Iowa, graduated from the electrical engineering course at Iowa State College in 1917. Completing the G-E student engineering course in 1918, he entered the mining section of the industrial department. In 1925 he was sent to Chile and Peru in South America on special industrial work for the International General Electric Company. On his return he resumed work in the G-E industrial department, becoming manager of sales of its mining and steel mill section on January 1, 1928.

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**Lincoln Electric Company,** Cleveland, Ohio, announces the moving of its Pittsburgh office, formerly at 323 Fourth Ave., to larger quarters at 926 Manchester Blvd. The office will be under the direction of F. M. Maichle, District Manager, and W. R. Persons and H. E. White, sales engineers.

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**The New York office** of the Crouse-Hinds Company, Syracuse, N. Y., is now located at 11 Park Place, Park-Murray Building. The office is under the management of C. M. Crofoot.

**H. E. Weiss** has been appointed manager of Allis-Chalmers Buffalo District Office, where he succeeds Mr. A. D. Brown recently transferred to Los Angeles. Mr. Weiss was formerly manager of the Company's Salt Lake District Office.

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**Howard E. Robinson,** whose election as vice president in charge of sales of The Otis Steel Co. was recently announced, has spent all his business life in the steel industry.

He started in 1910 with the Allegheny Steel Co. in the mill and continued there until 1917, when he enlisted in the army and saw service in France.

On his return in 1919 he rejoined Allegheny and in 1920, with the formation of the Newton Steel Co., became associated with the new concern as a sales representative in the eastern district with headquarters in New York. For the next several years he was in the Detroit and Chicago districts, becoming district sales manager in the latter city. In 1925 he was transferred to the main office of Newton at Youngstown, as assistant manager of sales, was elected general manager of sales in 1927 and vice president in 1932. He continued with Newton Steel Co. after its merger with Corrigan, McKinney Steel Co. until June, 1935, when he resigned to join Otis as general manager of sales. In his new position he succeeds Paul B. Allen.

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**500 members** and guests of the Pittsburgh section of the Association attended the monthly meeting held at the William Penn Hotel, February 29 to see the movies of the new hot strip mills of the Ford Motor Company and the Carnegie-Illinois Steel Corporation. These pictures were shown through the courtesy of the United Engineering and Foundry Company and Timken Roller Bearing Company. Members of the Chicago section will be privileged to view these on March 18 and the Cleveland section April 3.

**R. J. Eckstein** has been appointed manager of the Cleveland office of Cutler-Hammer, Inc., located at 1405 East Sixth Street.

Mr. Eckstein became associated with Cutler-Hammer twenty-five years ago. He started at the Milwaukee plant in 1911, and worked through practically every department before going to the Cleveland office. Past experience well qualifies Mr. Eckstein for his new position. A major portion of his career has been devoted to the application of electric control to motors in every phase of industry. In addition, he brings to his new duties a thorough knowledge of the other products of the company, such as lifting magnets, brakes, valve control, etc., for general application as well as for specific industries in the Cleveland territory.

R. J. ECKSTEIN

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**H. E. Ransford,** formerly vice president of the Henry N. Muller Company, Pittsburgh, is now located in the Fulton Building, Pittsburgh, where he will handle equipment for the industrials and power companies of this district.

Mr. Ransford was graduated from Rose Polytechnic in 1914 in electrical engineering, and previous to going into sales engineering work was in the electrical department of the Koppers Construction Company and acted as electrical engineer of construction with the Pittsburgh Steel Products Company. In 1918 he went into the sales engineering field with the W. A. McCombs Company, and in 1924 became vice-president of the Henry N. Muller Company. Mr. Ransford has been an associate member of the A.I.& S. E. E. for many years and has served as a member of the electrical developments committee.

**O. P. Robinson,** formerly associated with the Wisconsin Steel Works as a foreman in the electrical department, construction and maintenance divisions, has resigned to affiliate himself with the Chicago office of Cutler-Hammer, Inc.

Mr. Robinson was graduated from the Armour Institute of Technology in 1926 and received the degree of electrical engineering from this institution in June, 1935.

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**Harry L. Wilcox,** as announced in the February issue of the Iron and Steel Engineer, has been appointed assistant chief engineer of the Electric Controller and Manufacturing Company.

Mr. Wilcox was graduated from the University of Michigan in 1923 with a B.S. degree in electrical engineering. From 1923 to 1925 he was associated with the Westinghouse Electric and Manufacturing Company which company he left to join the Electric Controller and Manufacturing Company. During the world war Mr. Wilcox was an aviator in the Canadian Expeditionary Force.

HARRY L. WILCOX

O. P. ROBINSON

H. E. RANSFORD

**Alexander M. MacCutcheon,** Engineering Vice-President of The Reliance Electric and Engineering Company of Cleveland, Ohio, has been nominated for the presidency of the American Institute of Electrical Engineers. He was graduated from the Albany State Normal College in 1901, and taught mathematics and science in high schools until 1904, when he entered Columbia University. He was graduated in electrical engineering in 1908.

While employed by the Crocker-Wheeler Company, 1909-1914, he was successively in charge of engineering estimates, all estimates and proposals, and the drafting room, and also spent several months on alternator design. In 1914, he took charge of all new design work for the Reliance Electric and Engineering Company. He was appointed chief engineer in 1917, and in the fall of that year entered the U. S. Navy.

ALEXANDER M. MacCUTCHEON

At the time of his release in 1919 he was lieutenant in charge of fire control on the U. S. S. Louisiana. After returning to his former position early in 1919, he was elected a Director of the Company in 1920 and appointed Vice-President in Charge of Engineering in 1923.

Mr. McCutcheon joined the A.I.E.E. in 1912, becoming a Fellow in 1926 and was elected a Director in 1928. He is at present Chairman of the Lamme Medal Committee and a member of the Standards Committee.

In 1932 Mr. MacCutcheon was appointed as an Institute representative on the American Engineering Council. He was a member of the 1916 Annual Convention Committee and Vice-Chairman of the 1932 Convention Committee, being largely responsible for bringing that convention to Cleveland. He has been chairman of several committees of the Cleveland Section and was Section Chairman in 1920-21, being at present a member of the Section Advisory Board.

In 1917 Mr. MacCutcheon became a member of the Association of Iron and Steel Electrical Engineers. He has served on various committees for this body and has delivered numerous papers before this Association, where he is recognized as an authority on the subject of motor applications for steel mill auxiliaries.

# ∴ OBITUARIES ∴

**Robert W. Cousins,** an active member of the A.I.& S.E.E., and chief electrical engineer, Carnegie-Illinois Steel Corporation, Gary, Ind., died at Miami, Florida, February 18.

After graduating from college in 1902, Mr. Cousins was connected with the General Electric Company in New York City. In 1904 he left this company to go with the Illinois Steel Company at South Chicago. In 1909 he was promoted to the chief electrical engineer of the Gary works which position he held until his recent death.

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**Edward D. Frohman,** 62, vice president and general manager of the S. Obermayer Company, Pittsburgh, died aboard the Franconia near India, February 28, enroute on a world's cruise. Mr. Frohman was also a director of the Penn-Rilton Company and the Marine Manufacturing & Supply Company.

EDWARD D. FROHMAN

He was a graduate of Rose Polythechnic Institute in chemical engineering. His hobby was the collecting of valuable old books many of which were original copies. He was a member of the Pittsburgh Rotary Club.

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**Edwin E. Ellis,** vice president of the United States Steel Corporation, New York, died in Short Hills, New Jersey, March, 10. Mr. Ellis had been associated with the Corporation for the past thirty years. His first connection with the Corporation was as an assistant geologist for Oliver Iron Mining Company, Duluth, in 1906. In 1908 he was transferred to the Tennessee Coal Iron & Railroad Company, Birmingham, Alabama, where he remained for seventeen years, eventually becoming manager of the company's land department.

In 1925 Mr. Ellis was attached to the staff of the Corporation in charge of special mineralogical research, and subsequently was made president of the Universal Exploration Company, a subsidiary. In 1932 he was made a vice president of the Steel corporation.